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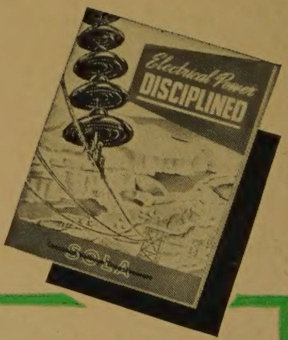

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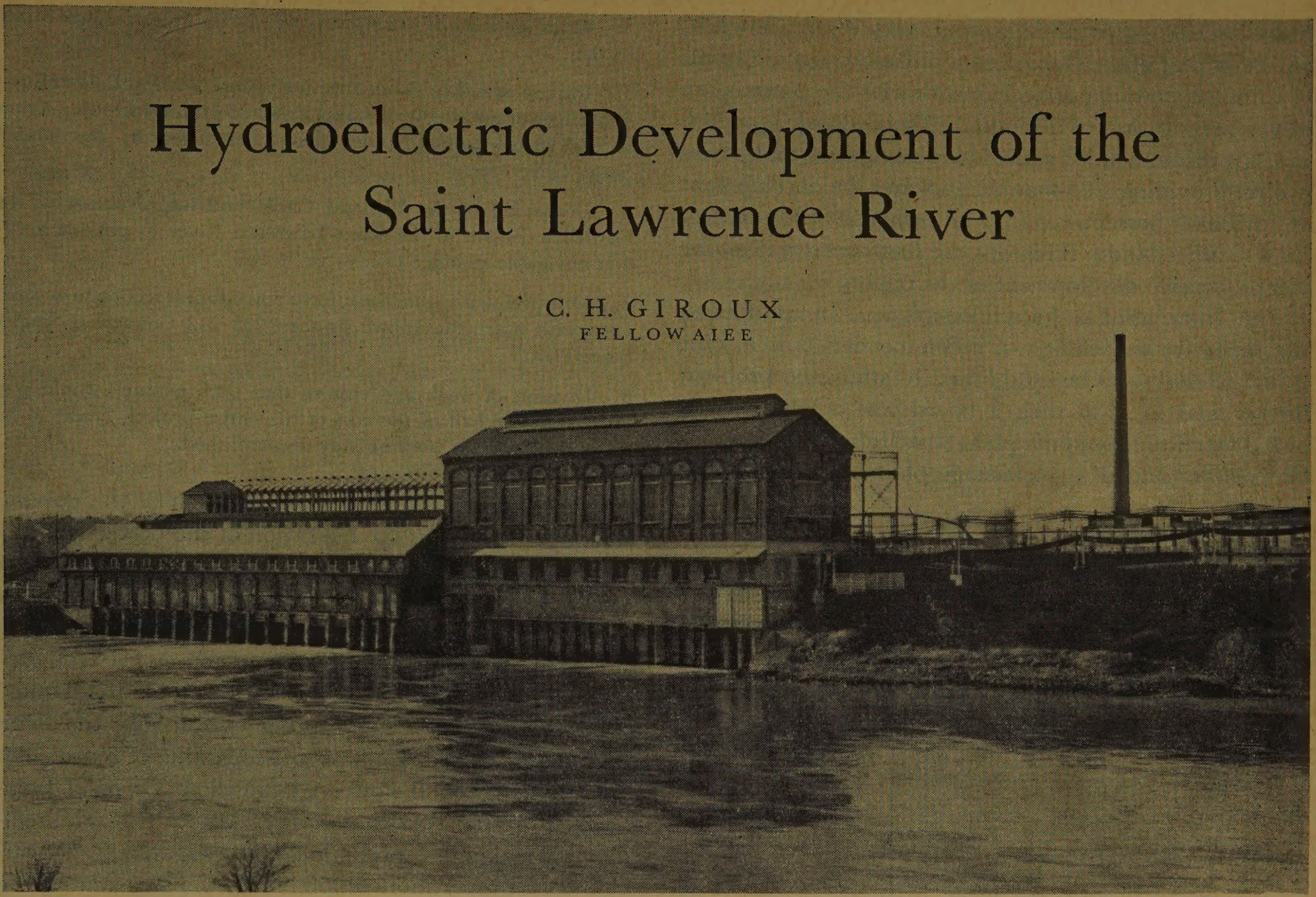
Hydroelectric Development of the Saint Lawrence River

C. H. GIROUX
FELLOW AIEE



Alcoa plant, Massena, N. Y.

Although that part of the Saint Lawrence River known as the "international rapids section" is potentially a promising source of hydroelectric power, little has been done thus far toward developing the region. However, a contemplated plan evolved jointly by Canada and the United States provides for improvement of the section for purposes of navigation and power.

THAT STRETCH of the Saint Lawrence River between Ogdensburg and Saint Regis, N. Y., known as the "international rapids section" has been scrutinized with longing for many years by proponents of hydroelectric power and of navigation from the Great Lakes to the Atlantic Ocean, but to date very little has been done toward developing the potentialities which are existent in this region. There is a navigation canal on the Canadian side with a depth of 14 feet and with lock dimensions of 252 feet by 44 feet, far too small to accommodate the large bulk carriers used elsewhere in the Great Lakes System or seagoing vessels which now must end their journey up the Saint Lawrence River at Montreal, Quebec, Canada. Alternate routes from the Great Lakes to the sea, using the New York State Barge Canal and the Hudson River, or the Illinois and Mississippi Rivers, can accommodate vessels of even less draft than can the Canadian Canal.

Hydroelectric development in this vicinity consists solely of a relatively small plant belonging to the Saint Lawrence River Power Company, fed by a canal leaving the Saint Lawrence River at the head of the Long Sault Rapids and discharging into the Grasse River near Massena, N. Y.

HISTORY OF THE PROJECT

A brief review of the history of the work which has been done, leading up to the presently proposed comprehensive project, may be of interest and will provide a better understanding of the situation as it now stands.

In June 1909, by treaty between the United States and Canada, a permanent organization known as "The International Joint Commission" was created, having jurisdiction over matters pertaining to boundary waters between the two countries. This body did nothing about the project in question until 1919 when the Congress of the United States requested an investigation of the Saint Lawrence River between Lake Ontario and Montreal. As a result, Colonel W. P. Wooten, United

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Essential substance of a paper presented at the Midwest Power Conference, Chicago, Ill., April 3–5, 1946.

C. H. Giroux is Special Assistant to the Chief of Engineers, United States Army, War Department, Washington, D. C.

States Army Corps of Engineers, and W. A. Bowden, chief engineer of the Department of Railways and Canals of Canada, were appointed to work with the commission in the preparation of a report. Their report, rendered in 1921, recommended a combined navigation and power project providing a 25-foot channel and the development of 1,850,000 horsepower in a powerhouse at the foot of Long Sault Island. This was the first concrete plan for comprehensive development of the region.

The International Joint Commission, in submitting the report to the Congress, recommended that a joint board of engineers be established to study the problem further and in 1926 such a board was created. This board failed to agree on a plan; the United States members recommended a single-stage plan, while the Canadian engineers recommended a two-stage development.[1]

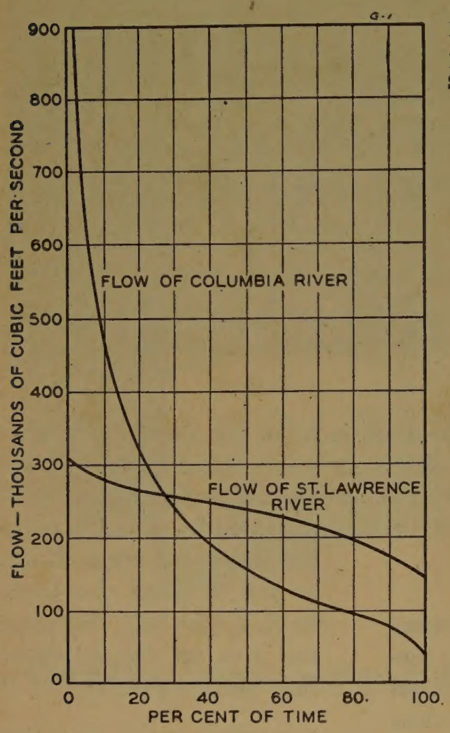

Figure 1. Comparison of flow of Saint Lawrence and Columbia Rivers

Subsequent to the foregoing, numerous reports were made and plans were proposed by Canadian and United States engineers culminating in the agreement of March 19, 1941, signed by representatives of the two countries, which provides for the construction of a complete project from the head of navigation on the Great Lakes to tidewater. The following are the principal features:

1. Equal division of water power in the rapids of Saint Mary's River.
2. Changes in the division of power now in effect at Niagara Falls.
3. Sole right of Canada to develop power in the Canadian section of the Saint Lawrence River.
4. Equal division of potential power in the international rapids section.
5. Improvements in the connecting waters between Lakes Huron and Superior and between Lakes Erie and Huron including a new lock at Sault Sainte Marie (since constructed by the United States Government).
6. Deepening of the Welland Canal and improvement of the Canadian section of the Saint Lawrence River to provide a 27-foot navigable channel.
7. Improvement within the international rapids section in accordance with a scheme known as the "238–242 Controlled Single-Stage Plan."
8. Division of work and cost so that each country would pay approximately half of the cost of the entire project, credit to be allowed for certain work already accomplished.

Further agreements were made by each of the governments providing for the operation of the power facilities and marketing of power by the Hydro-Electric Power Commission of Ontario and the New York State Power Authority. These agreements were incorporated in a bill which was not passed by Congress.

On October 16, 1940, the President of the United States issued an executive order establishing the Saint Lawrence Advisory Committee, consisting of representatives of the Federal Power Commission, Corps of Engineers, and New York State Power Authority, and directing the making of preliminary investigations and surveys and preparation of preliminary plans and specifications. In compliance with this order, the chief of engineers established the Saint Lawrence River District at Massena, N. Y., which, under the direction of Colonel A. B. Jones, and working in conjunction with the United States Advisory Commission, the corresponding Canadian committee, and other consultants, developed a project for improvement of the international rapids section of the Saint Lawrence River for navigation and power substantially in accordance with the previously mentioned controlled single-stage plan. This plan contemplates a navigation channel having a minimum depth of 27 feet with locks 800 feet long, 80 feet wide, and 30 feet deep over the sills. It also provides for the development of 2,200,000 horsepower of hydroelectric capacity. The subject matter which follows is based on the report prepared by the district engineer.

The project as recommended in the district engineer's report consists of the following principal features, supplemented by construction facilities; relocation of settlements, railways, and highways; navigation channel excavation, and dikes for the protection of certain property in the region which otherwise would be inundated by the power pool:

1. Iroquois Dam at Iroquois Point, to regulate the flow from Lake Ontario for the purposes of maintaining the lake level, and to aid in the formation of an ice cover in the winter season.
2. Point Rockway Canal and navigation lock to by-pass the Iroquois Dam.

3. Long Sault Canal and two navigation locks, by-passing the Long Sault Rapids.

4. Long Sault Dam at the head of Barnhart Island on the south channel of the Saint Lawrence River to create the power pool and to serve as a flood and emergency spillway for the pool.

5. Barnhart Island Dam and powerhouse at the foot of the island across the north channel of the river.

POWER POSSIBILITIES

From the standpoint of hydroelectric power, the Long Sault Rapids section of the Saint Lawrence River offers great possibilities because of the large regulated flow and the potential head which is available for development. Figure 1 gives a comparison of the flow of this river with that of the lower Columbia River, which illustrates the effect of the tremendous storage capacity of the Great Lakes on smoothing out the flow and thus enhancing the value of the water for power-generating purposes.

In order to obtain the full advantage of the potential head between Lake Ontario and the foot of the rapids, several schemes have been proposed in the past with one or more powerhouses in various locations, but the latest and most generally acceptable proposal is a single-stage project with the powerhouse located at the foot of Barnhart Island and development of a head which may vary from an extreme minimum of 71 feet to an extreme maximum of 87 feet. The normal head which was used for the design of the hydraulic equipment is 81 feet. Based on flow records extending over a period of about 80 years, it is computed that with this head and with the installation recommended, a firm capacity of 1,150,000 kw, firm annual energy of 10,110,000,000 kilowatt-hours, and average annual energy of 12,600,000,000 kilowatt-hours can be obtained at the site selected. Exhaustive studies of water utilization, cost, efficiency, space available, manufacturing facilities in the United States and Canada, and other considerations led to the conclusion that 36 generating units, each having a normal rating of 61,100 horsepower, will provide a well-balanced plant which will be practical, economical, and will make full use of the available resources.

The Harza Engineering Company, Chicago, Ill., was employed to make studies, estimates, and preliminary designs of the Barnhart Island powerhouse and related features. This company, under the general direction of the district engineer, and in collaboration with the advisory committee and other consultants, carried on the work which is described briefly in the following.

The powerhouse structure is 3,585 feet long and 180 feet wide, bisected transversely by the international boundary line. Starting at the center, each half includes one ice sluice at midstream, the powerhouse proper with one house service unit and 18 main units, and two more ice sluices at the shore end. Forebay level and downstream regulation is maintained by the operation of the spillway on Long Sault Dam, a separate structure at the head of Barnhart Island and on the south channel of the river.

The main turbines are of the Francis type designed to deliver 61,100 horsepower each at best gate and normal head of 81 feet; also 67,100 horsepower at full gate and the same head. The water capacity will be 7,200 cubic feet per second each at best gate, or a total of 259,000 cubic feet per second for the complete plant. Speeds of 69.2 rpm for the 60-cycle machines and 68.2 rpm for the 25-cycle machines were selected as giving specific speeds which would avoid objectionable cavitation and permit an economical generator design. The Francis type of runner was chosen in preference to the propeller type because of the higher permissible setting with less excavation which more than offsets the cost of higher speed generators which could be used with the propeller-type turbines.

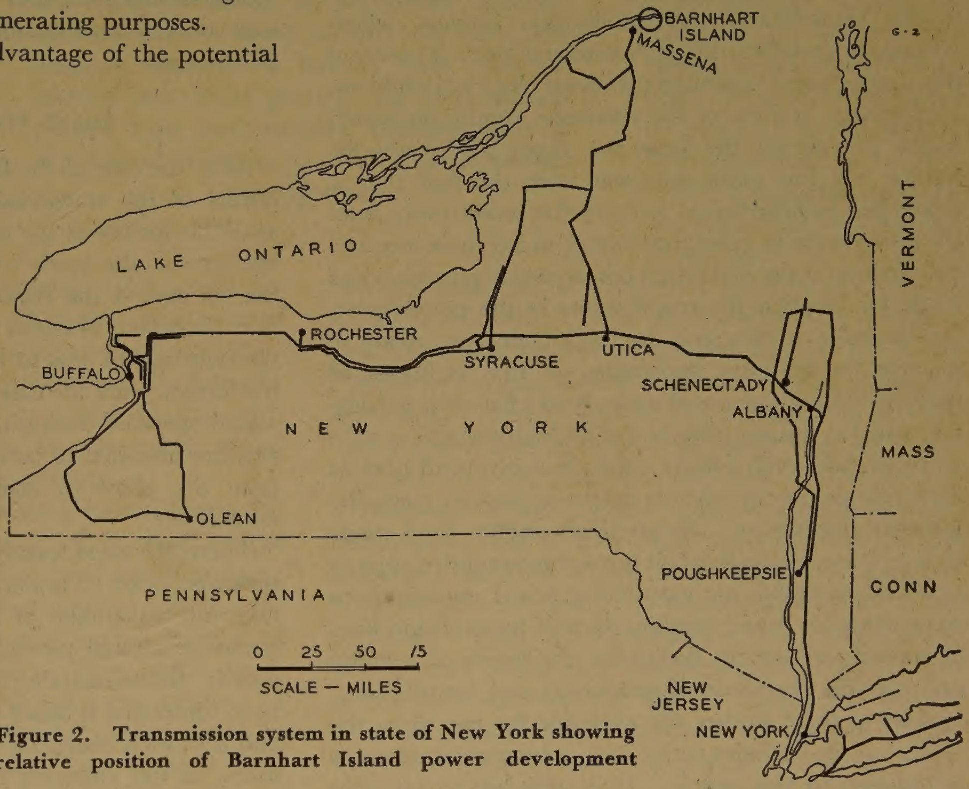

Figure 2. Transmission system in state of New York showing relative position of Barnhart Island power development

The main generators on the United States side, and six on the Canadian side, will be rated 55,000 kva at 95-per-cent power factor and will generate at 13.8 kv, 60 cycles. Due to the fact that a large part of the load of the Hydro-Electric Power Commission of Ontario is 25 cycles, 12 of the Canadian machines will be constructed for that frequency and rated 58,000 kva, 90-per-cent power factor. Generators are enclosed totally with integral air coolers but arranged so as to utilize the waste heat from them to augment the powerhouse heating system during the winter season.

Two units of 7,500 kva, 60 cycles, 13.8 kv, 80-per-cent power factor, 150 rpm, will be used to supply normal service for station auxiliaries, heating, and lighting.

POWER CONVEYANCE

The means for conveying power from the generators to the transmission and distribution systems, which necessarily must be utilized to market a block of power of this magnitude, constituted the major electrical problem, particularly in view of the unknown conditions which might prevail by the time the plant was ready for service. It was quite apparent from the first that it would not be economical to carry the power away from the powerhouse at generator voltage to a transformer and switchyard on the mainland, consequently provision was made for locating the transformers in the powerhouse. Innumerable studies and cost estimates were made of schemes for grouping generators on 13.8 kv busses, of utilizing individual transformer banks for each generator, and for transmitting power to high-voltage switchyards by both high voltage cables and overhead lines at such voltages as conceivably might be used to reach the ultimate destination. Short-circuit studies were made to determine required circuit breaker interrupting capacities, and extensive a-c calculating board investigations were made for many combinations of transmission lines of several voltages to determine the limits of stability and suitable reactance of generators and transformers. Results of these studies are available for use when the project again becomes active, but are too voluminous to summarize in this article. It is sufficient to say that feasible plans have been developed to meet almost any situation which may be existent when the project is built.

Figure 2 is a map of the transmission system within the state of New York as it existed at the time the report was prepared and the relative location of the plant at Barnhart Island. All of the major lines are nominal 110 kv, except for two running between the city of New York and Pleasant Valley which are 132 kv. The transmission system of the Hydro-Electric Power Commission of Ontario (not shown on the map) is partly 230 kv, 25 cycles, and partly 115 kv, 60 cycles.

The a-c calculating board studies of the Canadian system were made under the direction of representatives of the commission and were based on much more definite information than was available for the United States system. In studying the means for disposing of power generated on the United States side, many assumptions were made as to the amount of power which might be absorbed by industries in the nearby regions, the extent to which power might be utilized in the existing utility systems, and the requirements for long distance transmission to new markets or present heavy load centers. In this connection, the recommendations of the New York Power Authority and the Federal Power Commission largely were followed. The characteristics of existing transmission and generating facilities were obtained through the co-operation of the owning utility companies and utilized in conducting the studies. A comprehensive investigation of the limitations of a complete 115-kv transmission system with ties at Syracuse, Utica, Rotterdam, and Pleasant Valley was made, as well as of several combinations of 115-kv, 230-kv, and 287-kv lines.

PLANS FOR COMPLETION

As in the case of the facilities at the project itself, the results of the transmission line investigations will be available for use at the proper time. The only tangible outcome of the work which has been done along this line to date is the construction of 230-kv transmission lines between Massena and Taylorville, which were used during the war to supplement the power supply at the former point for making of aluminum. These lines, which operated during that time at 115 kv, are suitable and are intended to be used ultimately as main arteries from the plant to load centers which later will be established.

There are some features of the project which must be reviewed prior to undertaking construction in order to take full advantage of any new engineering developments or altered conditions since the report was prepared; fundamentally, however, the work which has been completed is based on sound engineering principles and is of such character and extent that construction of many of the elements can be started promptly upon authorization and the entire project can be carried to completion in accordance with an orderly program.

Inasmuch as the 1941 agreement between the governments of the United States and Canada has not been approved by the Congress, the project necessarily will be dormant until enabling legislation is passed. In order for the navigation facilities between Lake Ontario and the Atlantic Ocean to be effective, it also will be necessary for Canada to construct a suitable waterway below the international rapids on that part of the Saint Lawrence River which lies wholly within that country, as provided for in the afore-mentioned agreement.

REFERENCE

1. Senate document number 183, 69th Congress of the United States, second session.

Invisible Industrial Hazard

S. REID WARREN, JR.
MEMBER AIEE

With the growing use of X rays and gamma rays in the inspection of industrial products, it becomes increasingly important to acquaint both engineers and workers with the dangers to personnel engendered by the rays and with methods of protection from these dangers. Because of the "delayed-action" characteristics which render the radiations one of the most insidious of industrial hazards, safety measures must include not only preliminary protective barrier and distance factors, but must provide for periodic exposure tests and routine measurements of the dose of radiation to which a given worker is subjected.

X RAYS, AND GAMMA rays from radioactive materials, are increasingly common tools for the nondestructive inspection of industrial products. These radiations may injure workers seriously who are protected inadequately from them; their deleterious effects on the human body may be unsuspected for months or even years after exposure. Such an industrial hazard should be recognized by all engineers whose coworkers use these tools, as well as by the workers themselves. This article describes some of the properties of X rays and gamma rays and presents briefly the fundamental principles underlying the protection of workers from these radiations. It includes references to articles dealing with the specific practical methods of protection which have been devised and tested in industry.

There has been a very great acceleration during the past five years in the application of X rays, and of gamma rays from the radioactive products of radium, to the inspection of industrial products, and the increasing use of this powerful and useful method of inspection probably will continue. These highly penetrating radiations can be used to learn the presence or absence of defects within products of industry without destroying them. The inspection may proceed as a radiographic process which consists of the projection of a beam of radiation through the object to be inspected, and the recording of the shadows produced by the object on a piece of photographic film. This method provides an accurate and permanent record of the internal structure of the object. Alternatively, the X-ray shadow may be made visible by placing a fluorescent screen in place of the photographic film. In this case, the observer sees in a darkened room a pattern of shadows on the fluoroscopic screen, and he can perceive defects in the object by the proper interpretation of these shadows. This fluoroscopic method has the merit of being fast and economical, but it does not provide a permanent record. X rays also are being used increasingly in industry to study the crystalline structure of many industrial products. This is accomplished by means of X-ray diffraction apparatus.

The design and use of X-ray apparatus, and the use of radium in industry, have been accomplished by a relatively small number of specialists in this field. These specialists include metallurgists, physicists, chemists, engineers working for X-ray equipment manufacturers, X-ray technicians—many of whom have been trained in the medical field of radiology, and a few engineers in industry who are beginning now to learn about this new field of investigation.

Whenever X rays or gamma rays impinge upon living tissue, some cells of that tissue are destroyed. If the amount of radiation which traverses part of the human body is sufficiently small, no perceptible damage to the organism occurs. If the exposure is excessive, many painful and debilitating effects are produced. Many of the early workers who did not understand the destructive effects of X rays on living tissues suffered lengthy painful illnesses, disfigurement, and death.

At the present time there is adequate experimental evidence for the effective and economical protection of all workers in industry from these dangers. It is important that all engineers who may have to deal with the problems of installing and using X-ray equipment and radium in industry be informed properly of the dangers to personnel from these sources, and of the methods for minimizing these dangers.

EFFECTS OF RADIATION ON THE HUMAN BODY*

No precise description of the destruction of cells by X rays and gamma rays has been conceived. However,

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Essential substance of a paper presented at the AIEE summer convention, Detroit, Mich., June 24–28, 1946.

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Figures 1 and 2 are reproduced by permission of Doctor Barton Young, Temple University Hospital, Philadelphia, Pa.; Figure 4 by permission of L. S. Taylor, G. Singer, and *Radiology* (volume 22, 1934, page 445); Figure 5 by permission of C. B. Braestrup[9]; and Figure 6 by permission of George Singer[11].

* The subject matter of this section represents conclusions reached by roentgenologists, biophysicists, and physicists from very extensive research. The author is indebted to Doctor Robert P. Barden, department of radiology, Hospital of the University of Pennsylvania, who read this section and suggested modification which have been incorporated.

there are strong implications that the radiation, assumed to be a stream of relatively high-energy quanta, causes ionization of atoms within the tissue; and that such ionization causes a change in the chemistry of the cell within which such ions are formed. In general, this change is destructive so that the cell subjected to ionization by X rays or gamma rays may die. Different kinds of cells react differently to the ionization produced by the rays. Thus, the cells that are damaged most by a given amount of radiation rays are the reproductive cells, while those that react least are the muscle tissues. Other parts of the body are affected in a manner intermediate to the effects produced upon these most and least sensitive tissues.

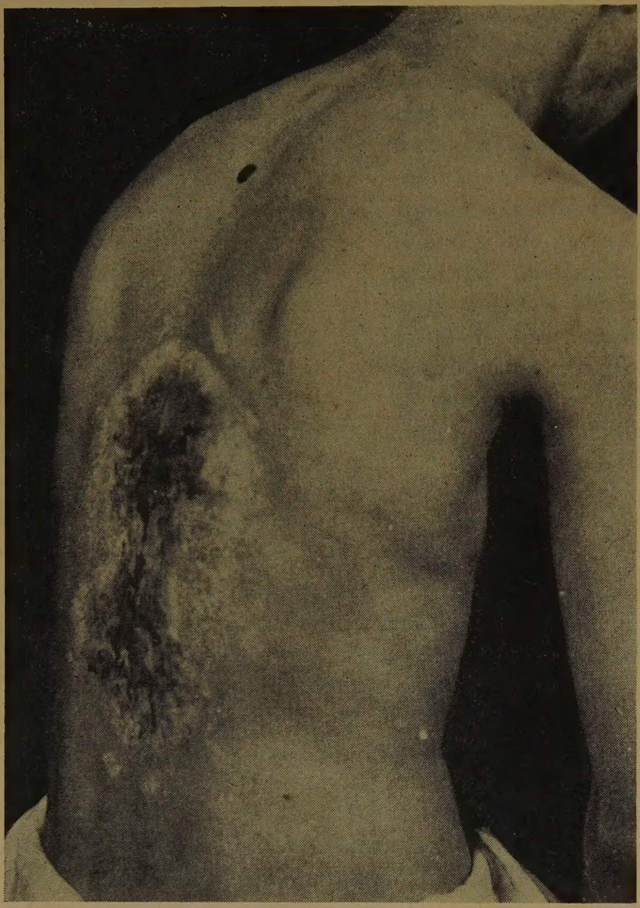

Figure 1. Excessive exposure during fluoroscopy 21 years before photograph was made

Although, as stated in the foregoing, the phenomena are not understood very clearly, it is agreed generally that the destructive effect of radiation upon tissue depends upon the amount of energy which is absorbed from the beam in the tissue. This opinion is the basis of a definition of the dose of X rays or gamma rays now internationally used in medical practice.

Small amounts of gamma or X rays do not cause sufficient destruction of cells to produce any known perceptible effect on the whole organism. Thus, protective measures need not have as an objective prevention of all such radiations from impinging on personnel, but only of reducing the amount to a specifiable minimum. However, it is not possible to reduce to zero the amount of radiation which falls upon a worker in the vicinity of X-ray apparatus or of radium.

THE PROTECTION PROBLEM

The problems of protection in the techniques of medical radiology have been analyzed carefully by radiologists and by physicists who have collaborated with these physicians. When X rays are used to make roentgenograms (X-ray films of parts of the human body) the amount of exposure never need be sufficient to produce a perceptible destructive effect. Thus, medical roentgenographic procedures supervised by competent roentgenologists and X-ray technicians are not dangerous. Neither is there great risk, under similar circumstances, of the patient's being injured by medical therapeutic radiation procedures. In these procedures the roentgenologist projects a gamma- or X-ray beam upon certain tissues which he hopes to destroy. At the same time he plans the treatment so that the destruction of nearby healthy tissue is not great enough to injure that normal tissue seriously. Furthermore, in medical practice so much attention has been paid to the problem of protection from radiation[1,2] that there need not be any danger to the roentgenologist, his technicians, or his patients.

The generalized and localized effects of excessive irradiation by X rays and gamma rays may be summarized as follows:

1. A preliminary decrease of the number of white cells in the blood followed by an accelerated and continued increase.[7,8]
2. Loss of hair.
3. Destruction of the metabolism of reproductive cells.
4. Production of "X-ray burns" which range from a simple nondestructive reddening of the skin to the production of an X-ray cancer or ulcer.

Figures 1 and 2 are examples of such deleterious effects. In both of these cases the insidious delayed action of these effects is demonstrated strikingly. The subject of Figure 1 was examined in 1925 by means of a fluoroscope. In this particular instrument it was apparently possible for the patient to be placed so that his skin was very close to the X-ray tube. Although the fluoroscopic examination probably proceeded normally, the patient's back was subjected to excessive radiation. Within a few weeks the back was reddened and sore. Now, 21 years later, the central portion of the lesion has become ulcerated, and the presence of malignant (cancerous) tissue is suspected. The patient who is the subject of Figure 2 underwent X-ray treatment for the removal of superfluous hair; treatment which neither was recommended nor carried out by a physician. Twelve years later the disfigurement of the legs shown in Figure 2 became evident.

Such facts as these establish the necessity of installing adequate X-ray and gamma-ray protection; and of testing routinely to be sure that protection is effective. These points cannot be overemphasized.

PROPERTIES OF X RAYS AND GAMMA RAYS

X rays and gamma rays are streams of quanta* which traverse a vacuum without attenuation; their attenuations as they traverse various gases, liquids, and solids depend upon both the properties of the beams of radiation *and* the properties of the beams of radiation *and* the properties of the absorbing material. Certain properties of X rays can be specified usefully in each of several ways, two of which are:

1. Energy W of maximum-energy X-ray quantum: $W=1.602\times 10^{-19}V$ joules; V being the peak X-ray tube voltage in volts.

2. Minimum wave length λ $\lambda=\frac{12,395}{V}$ angstroms; V being the peak X-ray tube voltage in volts (1 angstrom $=10^{-10}$ meter).

The energies of quanta of gamma rays commonly are measured by observing secondary effects produced when they interact with matter. It is inferred from such measurements that gamma rays are like X rays which would be produced by X-ray tube peak voltages up to approximately three megavolts.

The energies and the corresponding wave lengths of the quanta of a beam of X rays or gamma rays generally are spread over wide ranges. Relatively low-energy quanta are more likely to interact with matter than relatively high-energy quanta. Such interactions may occur in several ways:

1. The quanta may interact with atomic nuclei and thereby undergo a change in direction without a change in energy. Such quanta are called primary scattered quanta or rays, or unmodified scattering.

2. The quanta may impart to electrons all of their energies, thereby causing the electrons to be expelled from their parent atoms at velocities depending in each case upon the energy of the incident quantum and the energy required to separate the electron from the parent atom. Such events are called photoelectric absorption; the ejected electrons are called photoelectrons, and they have sufficient energy to cause the production of many more ions.

3. A quantum may impart to an electron a part of its energy, causing its ejection from its parent atom. In this case the quanta proceed with less energy (longer wave length) than they possessed as incident quanta. This process is called Compton scattering; the ejected electrons are called Compton electrons.

4. Quanta having energies greater than the energy corresponding to approximately 1,010 kv may be transformed into an electron and a positron, each having a velocity which depends upon the difference between the quantum energy and the energy (16.18×10^{-14} joules) corresponding to 1010 kv. This process is called pair production.

Each of the first three phenomena apparently occurs with both energy and mass unchanged before and after the event. On the other hand, in the fourth phenomenon radiant energy apparently is destroyed, and mass (the electron and the positron) are created. The theory of relativity correlates these facts. This theory leads to the conclusion that the "laws" of conservation of energy and conservation of mass should be considered as two approximations to a more general "law of conservation of mass-plus-energy." From this point of view, mass and energy are to be looked upon as two aspects of the same thing.

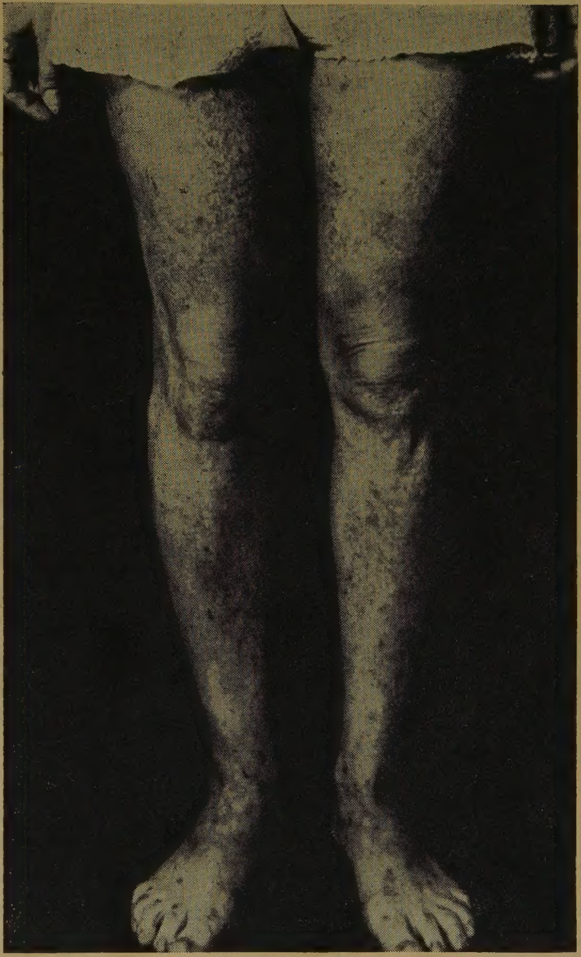

Figure 2. X-ray exposure for removal of excess hair 14 years before photograph was made

Initial exposure was not recommended nor carried out by a physician

The over-all effect of the phenomena that occur in the process of absorption is a reduction in the intensity of the beam of X rays or gamma rays, and a change in the spectrum, as the beam traverses matter; these

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[*] A quantum is a specific amount of energy whose velocity in a vacuum is 2.998×10^{8} meters per second. Beams of heat, light ultraviolet radiation, X rays, and gamma rays are streams of quanta.[3,4,5]

effects correspond to a loss of energy from the beam and most of this energy is lost as heat in the absorbing material. Some of the loss corresponds to the radiant energy of scattered radiation, ejected in all directions from the irradiated material.

The relatively high-energy quanta of an X-ray beam often qualitatively are called hard radiation. Such relatively hard radiation is attenuated less by a given thickness of a particular absorbing material than the relatively low-energy quanta which, in turn, are called soft radiation. Thus, the insertion of a filter (a sheet of metal) in a beam generally has the effect of absorbing more of the soft radiation than of the hard. Hence, the filtered beam is harder than the primary beam and more homogeneous.

Photoelectrons and Compton electrons cause, directly or indirectly, the production of many ions in the absorbing substance. For example, there may be several thousand ion pairs produced secondarily to the production of one photoelectron by the transformation of one quantum. When ions and electrons subsequently recombine, secondary X rays may be produced, characteristic of the substance which has been ionized. These secondary characteristic radiations are softer than the primary beam.[3,4,5]

The energy of a filtered X-ray beam or a filtered gamma-ray beam from an X-ray tube or from a radioactive material is not confined to a single wave length, that is, the beam is not homogeneous. Nevertheless, such beams approximate homogeneity closely enough so that the following properties of homogeneous beams are approximately valid for filtered beams. Homogeneous radiation undergoes an exponential decrease in intensity as the thickness of the absorber is increased. Thus, if x millimeters of a metal reduce the intensity of a homogeneous beam to one half of its initial intensity, $2x$ millimeters reduce it to one fourth of its initial intensity, $3x$ millimeters reduce it to one eighth, ... nx millimeters reduce the transmitted intensity to $1/2^n$ of its initial intensity. Quantitatively, the reduction per unit thickness is given by the linear absorption coefficient[3,4,5] which depends upon the wave length of the primary beam and upon the material. For a given wave length, the absorption coefficient is higher for elements of high atomic number than for elements of low atomic number (examples are given in Table I).

These theoretical points are introduced because they are fundamental to the measurement of the properties of the radiation which are of practical interest and to the accurate determination of adequate means of protection from unwanted radiation.

MEASUREMENTS

The theories from which the foregoing outline has been abstracted are based upon fundamental experiments. These experiments on X-ray beams and gamma-ray beams often are concerned with indirect methods of measuring energy, and energy per unit area per unit time—which is called intensity. These experiments are difficult to perform. They are not adaptable to the practical problems of measurement in industrial and medical radiology.

Practical measuring systems in this field conveniently are based upon relatively gross effects of radiation such as the production of ionization in gases, the darkening of photographic film, or the production of light by fluorescent materials. All three effects are used to control radiologic processes and all three effects are used to measure the effectiveness of protective measures.

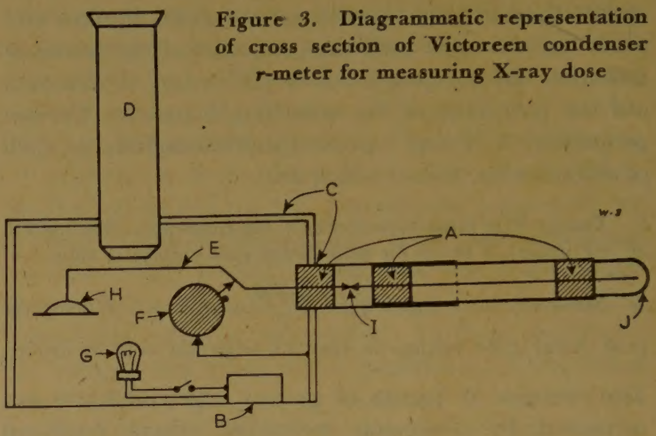

Figure 3. Diagrammatic representation of cross section of Victoreen condenser *r*-meter for measuring X-ray dose

A—Amber bushings
B—Flashlight battery
C—Lead shielding and chromium-plated steel case
D—Eyepiece
E—Metallized quartz fiber
F—Frictional device
G—Lamp
H—Quartz bow support for fiber, E
I—Contact
J—Chamber

Measurements based upon the ionization of gases are taken as practical standards, because these measurements can be reproduced relatively easily with an accuracy of plus or minus two per cent with generally available portable apparatus. Such ionization-measuring devices have been constructed in several forms. One of the most commonly used secondary standard instruments is the Victoreen condenser *r*-meter, the structure of which is shown in Figure 3. The chamber *J* is at the end of a metal tube which can be fitted into the socket at the end of the electrometer case. The case and tube are metalclad and are shielded with lead. The chamber itself is made of bakelite, and its inner surface is coated with graphite, which is connected electrically to the metal case *C* of the instrument. The second electrode of the chamber is an axial wire insulated by means of amber bushings *A*. When the chamber tube is inserted in the measuring instrument, the axial electrode is connected to the string of the electrometer by the contact *I*.

Within the case of the measuring instrument is a flashlight battery *B* and a lamp *G* which is lighted by pressing the switch in the side of the case. The lamp illuminates the metallized quartz fiber *E*, and its deflection can be observed through the eyepiece *D* which contains a calibrated scale. In order to use the device, the chamber tube is inserted in the measuring instrument and a knob on the side of the case is pushed toward the case and rotated. This causes a frictional device *F* to be rubbed against a contact; the result is that the string *E* and the axial electrode of the chamber are charged with respect to the case and the outer electrode of the chamber. The total capacitance of the instrument is approximately 50 micromicrofarads. When the device is charged fully the difference of potential between two electrodes of the chamber is approximately 400 volts. Under these conditions, the image of the string appears at zero on the scale.

When X rays traverse the chamber, which contains air at ambient temperature and pressure, electrons are knocked out and positive ions are formed. The electrons are attracted to one electrode, and the ions are attracted to the other electrode. This decreases the difference of potential and causes a change in the deflection of the fiber which can be observed by means of the eyepiece and scale.

The scale of the instrument is calibrated in roentgens. This unit is defined as follows:

> The roentgen shall be the quantity of X or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air, produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign.

The mass, 0.001293 gram, is the mass of one cubic centimeter of dry air at zero degrees centigrade and 760 millimeters of mercury pressure. Thus, if the instrument is calibrated in roentgens at a particular temperature and pressure (usually 20 degrees centigrade and 760 millimeters of mercury pressure) a correction must be applied to the reading for other temperatures and pressures. Although this definition of a unit of measure appears complicated, it is based upon careful analysis and test over a period of 40 years, and it now is accepted as an international standard. The unit has several important advantages. For example, the Victoreen condenser *r*-meter integrates the quantity or dose which it measures; that is, one measurement may produce a reading of 20 roentgens in two minutes while another measurement may produce a reading of 20 roentgens in four minutes. Although the doses in the two cases are equal, the dose rate in the first case is ten roentgens per minute, while the dose rate in the second case is five roentgens per minute. A second advantage is that the measurement is made in air so that measurements can be made either with no material interposed between the source of X rays and the chamber, or with various materials interposed. A third advantage is that the measurement disturbs the beam relatively slightly inasmuch as the energy absorbed by such a chamber is usually a minute fraction of the beam's total energy.

This measurement of quantity of X rays or dose often is used as a basis for the measurement of the quality or penetrating power of a beam. To make such a measurement the chamber is placed at a convenient distance from the X-ray tube and filters are placed successively over the window of the tube. Readings of the ionization chamber plotted against thickness of filter constitutes an absorption curve which is a clue to the quality or penetrating power of the radiation. It is common practice to plot as the ordinates of such curves the logarithm of 100 times the ratio of the reading with no filter to the reading with a particular added filter. The result is a logarithmic absorption curve, examples of which are shown in Figure 4. These particular curves show clearly that the radiation from a constant potential apparatus is attentuated far more greatly by a given thickness of copper when the tube voltage is 100 kv than it is attenuated when the tube voltage is 180 kv.

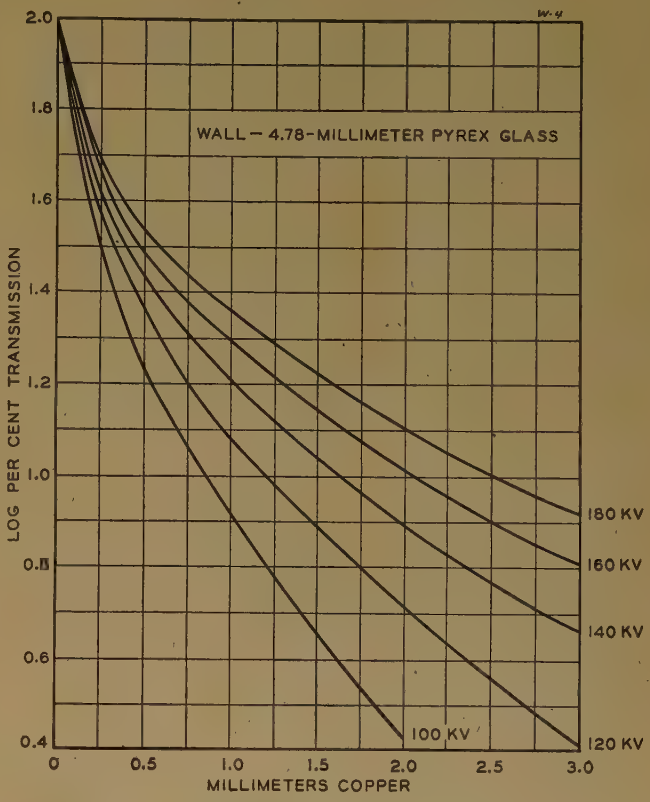

Figure 4. Logarithmic absorption curves in copper

It is often convenient to specify by a single number the penetrating power of a beam of radiation. By common consent the number which is used for this purpose is the half-value-layer. For example, from the 180-kv curve of Figure 4, the logarithm of the per cent transmission through a filter of 0.50 millimeter of copper is approximately 1.535. The thickness of copper which will reduce the dose rate to one half is that thickness which reduces the logarithm of the per cent transmission by 0.301 (= log 2). The logarithm per cent transmission for 1.40 millimeters of copper is 1.234. Thus, the half-value-layer for 180-kv radiation emitted through a 0.50-millimeter copper filter is 1.40 − 0.50 = 0.90 millimeter of copper.

The material which conventionally is used for measuring half-value-layer varies with the quality of the radiation. The following limits and filter materials are recommended by the standardization committee of the Radiological Society of North America:[6]

For qualities measured in hvl (half-value-layer)—
Use cellophane up to hvl = 2 millimeters, above which
Use aluminum up to hvl = 2 millimeters, above which
Use copper up to hvl = 2 millimeters, above which
Use tin up to hvl = 2 millimeters, above which
Use lead, for all hvl.

PROTECTION OF PERSONNEL

It can be seen from the absorption curves of Figure 4, and deduced from the measurements of the phenomena mentioned in the preceding, that an absorber cannot absorb the energy of an X-ray or gamma-ray beam completely no matter how thick it is. Furthermore, as has been noted, the absorption of a small amount of radiation by the human body probably is not harmful. Thus, the problem of protection can be attacked in three steps:

1. A choice by physicians and other workers in the biological sciences of a tolerance dose which is the number of roentgens to which the individual can be subjected safely.

2. The economical choice of protective methods which will guarantee that the personnel are not subjected to more than the tolerance dose.

3. Means for testing the protective methods to be sure that they are effective.

The choice of the tolerance is a controversial problem. At the present time the generally accepted tolerance dose is 10^{-5} roentgen per second for a 7-hour daily exposure if the worker has a month's vacation each year. Some biophysicists allege that this tolerance dose is too high, and they recommend that it be reduced by a factor of 10. In spite of these criticisms the larger amount (10^{-5} roentgen per second) generally is used at the present time. A commonly discussed intermediate tolerance dose is 0.1 roentgen per day which is somewhat less than the rate 10^{-5} roentgen per second; both being considered in relation to a 7-hour working day. Incidentally, the rate of the 10^{-5} roentgen per second is approximately 10,000 times the dose rate attributable to cosmic rays.

Table I. Examples of Linear Absorption Coefficient

$I=I_0\epsilon^{-\mu x}$; I_0 Is the Initial Intensity, I Is the Intensity Through a Thickness x Centimeters of a Material Whose Linear Absorption Coefficient Is μ Centimeters^{-1} for the Wave Length Specified

Absorber	Linear Absorption Coefficient λ = 0.63 Angstrom	 λ = 0.098 Angstrom
Carbon	1.05	0.32
Copper	322	2.89
Lead	1,078	38.5

Committee Z 54 of the American Standards Association in preparing a "War Standard" Safety Code for the industrial use of X rays and gamma rays agreed upon a permissible daily dose of 0.1 roentgen.[16]

The problems of choosing protective methods which will assure that the operators of industrial radiation equipment will be subjected to less than the tolerance dose are quite complicated, and relatively few workers at the present time are competent to devise such protective methods. The following will outline some of the principles which are involved but will not attempt to present detailed methods for working out plans for protection.

Two fundamental principles to be applied to the problem of protection are:

1. As much protection as possible should be provided as near the source as possible.

2. While exposures are being made, every worker should be placed as far as possible from the source of radiation and from material upon which the radiation falls.

The two factors which are most economical in providing adequate protection are the distance from the source, and the insertion of lead, concrete, or other absorbing material so that it will absorb a large part of the radiation which otherwise would strike the worker. The factor of distance cannot be overemphasized. The radiation from a source decreases inversely as the square of the distance from the source. Thus, to give a specific example, if the operator is situated so that he is subjected to irradiation at the rate of 4×10^{-5} roentgen per second, it is possible that he can be protected adequately if his position is changed to one which is twice as far from the source as his original position. Although such a simple case as this is not likely to occur in practice, it is an excellent example of economical protection which occasionally can be provided by distance alone.

Of the protective materials, lead is the most effective practical material per unit thickness at 400 kv peak or less. The dose rate for filtered 200-kv-peak X rays can be reduced by a factor of 1,000 by an addition of approximately 3 millimeters of lead; at 400 kv approximately 12 millimeters of lead would be required to produce the same reduction in dose rate. However, as the required thickness of lead becomes greater than about one half inch, it becomes increasingly expensive to buy and to install. Therefore, for extremely high voltages and for gamma-rays very often it is economical to use concrete even though the thickness of concrete is greater by a factor of the order of 15 than the thickness of lead required to produce the same absorption. A general inference would be, therefore, that up to 400 to 500 kv peak, lead would be used as the protective material; while from 500 kv peak upward, concrete may be expected to be the more economical material. It must be emphasized, however, that great care in the installation of concrete must be exercised. For example, suitable kinds of concrete building blocks may be used only if the cracks between blocks are plugged properly with cement so that the absorption between these bodies is equivalent to the absorption through the blocks themselves. Of particular value for learning the details of measurements in this field are articles by C. B. Braestrup and L. S. Taylor.[9,10]

Table II.* X-Ray Protection Required to Reduce the Direct Radiation to 0.1 Roentgen Per Day

Protection Is Given for Different Exposures Per Day Indicated in Milliampere-Minutes and Corresponding Milliamperages for Continuous Operation

Distance		400 Kv								1,000 Kv							
		1,500 Ma-Min (3 Ma)				2,500 Ma-Min (5 Ma)				500 Ma-Min (1 Ma)				1,500 Ma-Min (3 Ma)			
	Feet	Lead		Concrete		Lead		Concrete		Lead		Concrete		Lead		Concrete	
Meters	(Approximate)	Mm	In.	Cm	In.	Mm	In.	Cm	In.	Mm	In.	Cm	In.	Mm	In.	Cm	In.
1	3	17.5	11/16	30	11 3/4	18.5	3/4	31	12 1/4								
2	7	14.9	5/8	26	10 1/4	15.8	5/8	27	10 3/4			88	35			105	41
3	10	13.4	9/16	24	9 1/2	14.3	9/16	25	9 3/4			77	30			93	37
4	13	12.2	1/2	22	8 1/2	13.2	1/2	23	9 1/4			68	27			84	33
5	16	11.3	7/16	21	8	12.4	1/2	22	8 3/4			63	25			78	31
6	20	10.7	7/16	20	7 3/4	11.7	1/2	21	8 1/4	73	2 7/8	58	23			73	29
8	26	9.6	3/8	18	7	10.5	7/16	19	7 1/2	67	2 5/8	52	21			65	26
10	33	8.7	3/8	17	6 1/2	9.7	3/8	18	7 1/4	63	2 1/2	46	18	73	2 7/8	58	23
20	66	6.1	1/4	13	5 1/4	7.1	1/4	15	5 3/4	49	2			60	2 3/8	43	17
30	98	4.6	3/16	11	4 1/4	5.5	1/4	12	4 3/4	41	1 5/8			52	2		
40	131	3.5	1/8	9	3 1/2	4.4	3/16	10	4	35	1 3/8			46	1 7/8		
50	164	2.7	1/8	7	2 3/4	3.6	1/8	9	3 1/2	30	1 1/4			41	1 5/8		

* Reproduced by permission of C. B. Braestrup.[9]

Throughout this field of investigation there are relatively few experimental data particularly for X-ray tube voltages higher than 400 kv peak. For this reason three sets of data are reproduced from the afore-mentioned articles. The first, Figure 5, is a chart from Braestrup's article.[9] This chart is a compact summary of information concerning how much lead protection is required in various circumstances likely to be encountered in practice. Information derived from the chart, in the form of a thickness of lead, is likely to provide a factor of safety, for various reasons to be discussed. Three numbers are required to "enter" the chart:

1. Either the total milliampere-minutes of exposure for a day of 8.3 hours or the X-ray tube current in milliamperes.
2. The distance of the operator or other worker from the X-ray tube, in meters or feet.
3. The X-ray tube peak voltage in kilovolt peak.

From these three numbers, the chart can be used to find that thickness of lead which should be inserted between the operator or other worker and the apparatus which will reduce the dose to him to less than 0.1 roentgen per day. For example, if the X-ray tube current is 10 milliamperes, the distance from operator to tube is 16 feet, and the X-ray tube voltage is 250 kv peak, proceed as follows. Find the diagonal line whose intersection with the ordinate scale on the left is marked 5,000/10; this diagonal line represents exposure of 5,000 milliampere-minutes, or continuous operation during an 8.3-hour day at 10 milliamperes. Next, find the diagonal line whose intersection with the ordinate scale on the right is marked 5/16; this diagonal line represents a distance from operator to tube of 5 meters ($\approx$ 16 feet). Follow these diagonal lines to the point of their intersection, then proceed vertically to the curve marked "250 kv peak"; the thickness of lead horizontally opposite to this point, on the scale of ordinates, is the required thickness of lead. In this example the result is 6.2 millimeters of lead. Note that, if 10 milliamperes 250 kv peak is the maximum rating of the X-ray apparatus, protection by 6.2 millimeters of lead is likely to exceed the requirement because it is unlikely that the equipment will be operated continuously at full rating.

TUBE SHIELDING

It has been noted that economical protection includes lead near the X-ray tube. In most modern apparatus the X-ray tubes are covered by a grounded metal shield; lead is incorporated within this shield. Thus a beam of high dose rate is emitted only from a port provided for the primary radiographic beam. If this beam always is made as small as possible by means of a lead diaphragm or lead-lined cone, and if the primary beam always falls on the object to be radiographed, it is practically impossible for the operator or other worker to be in the path of the direct beam for which the protective thickness of lead derived from Figure 4 would be required. However, if less lead is used, there is danger that the equipment may be operated with no absorbing object in the direct beam, thereby endangering the personnel. Inasmuch as such errors in operation can occur, the most conservative protective measures are to be recommended.

The second, Figure 6, is a chart from Taylor's article[10] which provides information on the use of concrete as protective material. The data for this chart were derived from extensive measurements described in detail in a publication of the United States Bureau of Standards.[11]

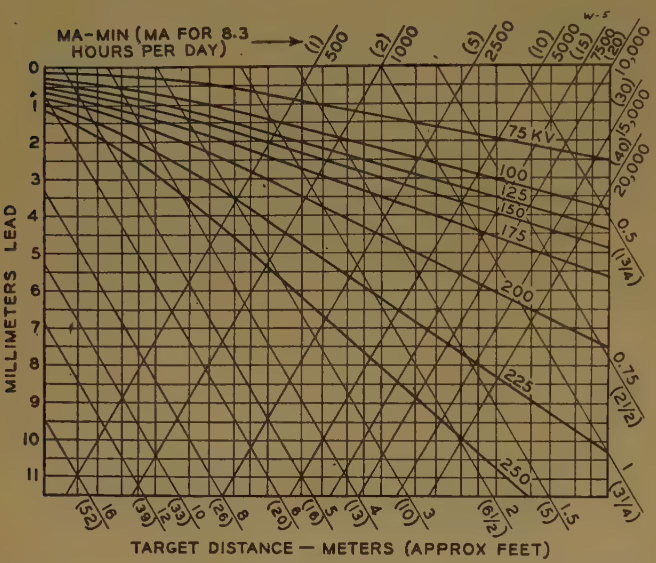

Figure 5. Chart for determining thickness of lead required to reduce dose rate to 0.1 roentgen per day if kilovolt peak, milliamperes-minutes, and distance are known

The third item, Table II, is reproduced from Braestrup's article.[9] The data of this table are thicknesses of lead or concrete required at 400 kv peak and 1,000 kv peak for adequate protection at various distances. These data supplement the data of Figure 5.

ERRORS IN PROTECTION DESIGN

Although shielding from the direct beam is the most important problem of protection, errors in designing protection occur most often because of failure to deduce the path of scattered radiation. For example, an operating booth well protected on the four vertical sides is little more than a trap if scattered radiation enters through the top or bottom of the booth. On the other hand, it is unlikely that the top and bottom of such a booth or some of the vertical sides need contain as thick lead as one or two of the vertical sides which may be subjected to the greatest exposure. Thus the problem of providing protection which is at once safe and economical is seldom a simple problem.

The protection of outside walls requires special consideration. If no one works outside such a wall at distances such that the exposure is greater than 10^{-5} roentgen per second, no protective barrier need be used, with one possible exception. The exception is: if the radiation through a wall irradiates a scattering object so placed that scattered radiation from it may expose workers excessively, the wall, or at least a part of it, must be shielded by lead or other absorbing material.

Protection from gamma rays is accomplished far more economically by distance than by protective barriers. The attenuation of filtered gamma rays in lead is approximately one half for a thickness of one centimeter. Therefore, only very thick and expensive lead barriers would be effective; such thicknesses, for various amounts of radium, are given in a chart in a handbook of the Bureau of Standards.[2] Radium should be stored in a safe having within it a lead case no thinner than five centimeters in which the radium is placed. It should be carried in such a way that it is surrounded at all times by several centimeters of lead and in such a way that it is never nearer than one meter to the person who is carrying it. Tubes containing radium should be moved by means of forceps, and there should be a lead barrier five centimeters thick between the operator and the tube.

MEASURING SAFETY

The installation of protective measures marks the beginning, not the end, of the prevention of excessive exposure of workers to X rays and gamma rays. Regularly repeated tests of the exposure of workers are necessary. Complete blood counts on all who work regularly near X-ray apparatus or radium should be made every two months[1] and approximate measurements of the X-ray or gamma-ray dose to which each worker is subjected should be made routinely.

Although normal, dark-adapted eyes can perceive the illumination of a fluoroscopic screen which is subjected to X rays with a dose rate of the order of 10^{-5} roentgen per second, this method seldom is used to make routine tests of protective barriers. The fluoroscopic method has two disadvantages for routine testing: the results are not quantitatively accurate; and the method measures dose rate rather than dose (integrated). Nevertheless, a piece of fluoroscopic screen is useful to spot-check a protective installation; particularly to test for leakage through cracks in walls or around the edges of lead-lined doors.

The Geiger-Müller counter is also a very sensitive radiation detector. It has approximately the same disadvantages, and the same field of usefulness as the fluoroscopic screen. Recently designed counters are calibrated in microroentgens per second; increasing use of these new devices may be expected.

Convenient and satisfactory tests can be made by means of dental X-ray films. A strip of lead about 1/8-inch wide by 1/16-inch thick, or a paper clip, is fastened on both sides of the film packet, which is light-tight. This combination is carried by a worker for several days, and the film then is processed. The approximate exposure in roentgens can be determined by comparing the density of the test film with the density of a similar film exposed in a beam of known dose rate for a known time. If the shadow of the lead strip or paper clip is imperceptible, the bearer of the packet has not been exposed excessively to X rays.

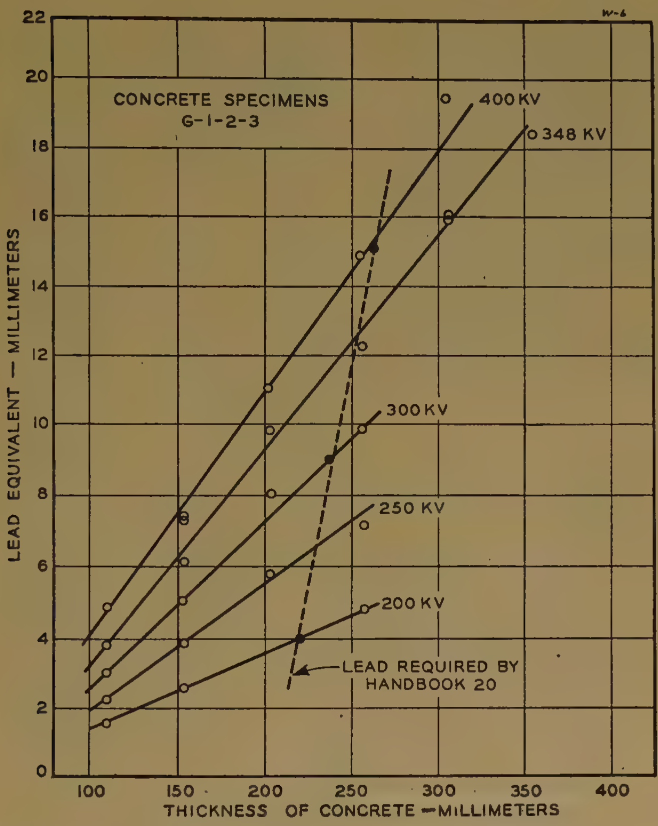

Figure 6. **Thickness of poured concrete required to provide same protection as lead**

The most satisfactory method for measuring the radiation to which a worker is exposed is for him to wear a calibrated ionization chamber throughout a working day, and to measure in roentgens the daily exposure. There is available for this purpose an electrometer and charging device operable from a 110-volt 60-cycle source and as many chambers, each having the appearance of a fountain pen, as may be needed. Each chamber can be charged, and carried by a worker for one day. At the end of the day, each chamber is inserted into the electrometer to measure the total exposure, in roentgens, to which it has been subjected. The full-scale reading is 0.1 roentgen.

CONCLUSION

The "delayed action" of X rays and gamma rays as destroyers of living tissue render these useful radiations one of the most insidious of industrial hazards. As it would be uneconomical, if not impossible, to provide perfect protection to all workers from these hazards, practical industrial radiographic, fluoroscopic, and diffraction installations are not foolproof. If they are designed well and installed competently, such installations may be safe if supplementary rules are specified and obeyed by all workers. Some of the points to be considered in formulating such rules are:

1. Never subject any part of the human body to the direct beam from an X-ray tube or radioactive material.
2. Never assume that a worker is safe; always measure the radiation at his location under regular operating conditions.
3. Never operate an X-ray tube without an absorbing object in front of it.
4. Never permit a worker to be in the path of the primary beam from an X-ray tube, even if an absorbing object is placed between him and the tube.
5. Always remember that radiation may scatter around the edges of a vertical protective barrier.
6. Never touch a radium container and never place one in the pocket of a piece of clothing.
7. Make routine blood tests and physical examinations of workers.
8. Make routine tests to prove that the protection and the operating rules are effective.
9. Provide 4-week vacations for X-ray and radium workers.
10. Report the results of tests to employees in order to emphasize both the need for vigilance and the reward for it.

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Science, Strength, and Stability

VANNEVAR BUSH
FELLOW AIEE

The strength and stability of any plan for world peace must be drawn from the states composing it and these states, in turn, reflect the thinking of their people as expressed through public opinion. Thus, the engineer and scientist, as members of a profession with its attendant responsibilities to the public, must be prepared to contribute their share to the formation of the enlightened world opinion that is essential for the development of understanding between nations.

THE international peace which is demanded by thoughtful men the world around is not the mere absence of war. It is something far more positive than that—it is a condition of amity and cordial collaboration among independent national groups, each confident in its own vigor, within an international framework. It thus is dynamic, not static; progressive, not stagnant; pioneering in all fields where general betterment of man's spiritual and material life may be expected. We have not had it for many a long year. We do not have it now. Yet we know that it must be secured if the human race is to continue, and we have faith that ultimately it can and will be assured.

But faith without work is not enough. For the boon of this peace to be attained, and for the heart-rending scourges of destruction, disease, famine, and despair to be lifted throughout the world, there is work, much and great work, to be done. It is only as all types and conditions of men do their share unselfishly that there can be created in each of the peoples of the world the self-confident vigor which is the essential precursor of unstinted world collaboration. Whatever the ultimate world system toward which we are tending, whatever may be surrendered of individual sovereignty by the nations in the interest of that system, its strength and stability will have to be drawn from the several states composing it. Recognizing this imperative condition, we recognize that the first task laid on every group in America's wonderfully varied population is for each group to give, seriously and consciously, its best effort toward the creation—and the enhancement—of strength and stability in the United States.

TECHNOLOGY AND PEACE

We are concerned, in this article, with the general subject of technology and international peace. What is technology? As contemplated here, it cannot be regarded in isolation. It cannot be considered apart from the science out of which it grows and the engineering through which it is usefully expressed. We must deal with all three of these concepts; basic research, applied research, engineering. Let us then, for convenience, primarily consider science, the general area in which all three concepts operate. How then, may scientists aid in the establishment and growth of the national strength and stability essential to amity and active concord among nations?

Democratic government, to the philosophy of which Americans are committed by heritage and by belief, and under which they have prospered, depends for effectiveness upon the quality—the thoroughness, substance, and keenness—of public thinking on the major issues of the day. The acts of a democratic government are truly the acts of the people whom that government, by their consent, represents. If acts of such a government are faulty, shortsighted, unjust, they are so because the people have been heedless, selfish, unthinking; and those faulty acts will stand uncorrected until such time as the people are roused from lethargy to serious thought which will crystallize in better action.

Public thinking which comes to expression in government action is the product of two forces. One of these, like the sparks over a lava flow, is spectacular and dramatic. It is the force exerted by the extreme pressure group rallied for specific action on an immediate issue or marshaled for continued agitation in support of some special interest. At times it can extend to coercing government while working lawfully within the frame of government. It is essentially direct action for self-interest. Not all direct action, fortunately, is of this kind; men can apply their energy and their skill directly to public problems with no self-seeking, and men do, as we all know. There is need of more such men.

The second force in the formation of public opinion, like the lava flow itself, moves more slowly and with far less superficial drama. It is a vast force, and in the end produces fundamental change. This is the force that operates through the long-term development of matured public opinion by the gradual influence of enlightened and disinterested citizens. Government

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Essential substance of an address presented at a symposium on "The Technology of International Peace," Walker Memorial, Massachusetts Institute of Technology, Cambridge, Mass., June 8, 1946.

Vannevar Bush is president, Carnegie Institution of Washington, Washington, D. C.

by the people is really government by that portion of the people which takes the trouble to participate actively in the forming of public opinion. It is this fact which explains the feeling of responsibility for discussion of public questions and for sincere consideration of them—the feeling that every thoughtful man has experienced.

Professional groups in the United States particularly are aware of this feeling of responsibility—this duty—to take a conscious part in guiding the growth of public opinion and thus in shaping the forces which result finally in governmental action. This is a serious matter; it is no light thing for a man or a group to undertake deliberately to evoke and direct such forces. But professional men realize that theirs is a special obligation, for they must recognize that they, in their education and professional training, have benefited especially from the existence of organized society. They realize, too, that they stand in a unique relationship to other groups in the population and in a unique relationship to the population as a whole, and that the implications of that relationship are extremely important, not merely to them, but far more to the people in general. This realization always has rendered professional groups reluctant to plunge into militant partisan political action, for fear of jeopardizing that relationship. Yet, by acceding to this requirement for caution, they impose uneasiness upon themselves, for the recognized obligation—the social debt—still stands, and they are concerned over it.

THE PROFESSIONS AND PUBLIC OPINION

To understand what this unique and socially valuable relationship is, and whence it comes, both defines the idea of a profession and explains the origin of the professional man's concern over the question of how and how much he shall participate in the formation of public opinion. The hallmark of a profession is ministry to the people; the disinterested and authoritative employment of special or superior knowledge for the counseling and the safeguarding of others. Ministry in this sense is much more than service; it is marked by ideas of dignity and authority, especially the authority arising from special training, special competence, or high ethical conduct. Ministry is performed when one who has become adept in higher knowledge through his devotion and study draws upon that knowledge authoritatively for the benefit of other people. That the idea of ministry is accepted by the people needs no demonstration; their acceptance of it is signalized by the prerogatives which the professional man is allowed to maintain, by his distinctive place in society, which is his because the people have reason for confidence in the integrity of his profession and for belief in its general beneficence.

That confidence and that belief are derived in some measure from the public's respect for the body of knowledge in which a professional group is adept and which it administers; a respect based both on the fact that the knowledge is personally valuable to the individual citizen and on the fact that the dignity of tradition and long heritage clings to it. In larger measure, however, the confidence and belief of the public in the beneficence of a profession are based on the fact that in their ministry of the people the members of that profession are disinterested, seeking first and foremost only to perform their ministry honestly and ably as required by their self-imposed code of ethics. This statement does not imply that ministry inevitably demands a vow of poverty. If he is to be truly effective, the professional man properly may insist that he receive for his work a material return adequate to keep his mind free for full and effective performance. But his interest in material return is secondary. If it becomes primary, he ceases to be a professional man.

Inasmuch as the authority and dignity which the professional man must have for the full performance of his professional function rely so heavily upon the fact that he is recognized as free of a controlling self-interest, it is natural enough that he should weigh carefully the matter of participation in political affairs. If he compromises his disinterestedness, he risks prejudicing his ministry. And he knows the importance to the people that that ministry be not prejudiced. At the same time, he cannot but recognize that the disinterestedness of the professions often can supply a highly needed balance wheel in social mechanisms, and that very often the authority of the professions in their own callings may lead the people to look to them for sound counsel on other matters.

For emphasis, I have set this dilemma out in large and plain terms, taking the hazard of overstating it in order to gain the advantage of putting it bluntly. We know that professional groups sometimes resolve it, for we know that they can and do contribute to strength and stability in government by directly sharing in and influencing the public thought on which these depend. On some occasions they have done so at no inconsiderable risk to their unique relationship to society, yet I believe that even that risk usually can be avoided. It is instructive to review summarily the general course which some of these groups have followed.

CONTRIBUTIONS OF THE PROFESSIONS

The clergy, whose position as a professional group is most clearly a consequence of ministry to the people, for centuries have contributed to governmental vigor by their influence as a profession quite apart from their most profound personal influence as men of God. More and more in recent times they have taken the route of direct action, with all that implies of committees, petitions, signatures on manifestoes, and other activities, very often having to do with issues most remote from the professional competence of the individuals involved. In all likelihood, however, the vital effectiveness of the clergy in raising the general moral tone of the public mind, in increasing our responsiveness to humane values, has come in greater measure from the long-range indirect influence which is characteristic of true ministry, and there is serious question within the profession itself whether the superposition of direct activities is worth what it costs. In fact, this question is as old as organized religion itself.

The profession of medicine, with its long and distinguished history, its high degree of organization, and its unique code of professional conduct epitomized in the time-honored Hippocratic Oath and vigorously maintained by the traditions of the profession, had and has great power and influence. We have seen sweeping changes in public thinking about sanitation, public health, and similar matters in the past century. Yet it is only a little more than 100 years ago that Doctor Benjamin Waterhouse, in Cambridge, Mass., was but a voice crying in the wilderness. The enlightenment that has come in the century since his time is testimony to the force which medical men have exerted. They have contributed greatly, as individuals and as a professional group, to the development of a public responsiveness and receptiveness that not merely accepts but actively demands legislation unthinkable 100 years ago. In the main, moreover, the profession of medicine has secured these and other good results not by short-range direct action, but rather by its long-range influence on the public mind.

Resembling medical men in their holding of a particularly specialized place in the community, in their firm and comprehensive organization, and in their administration of self-imposed standards of professional conduct, lawyers as a profession are set apart by the fact that in a government which is of laws and not of men they stand, necessarily, in a special relation to public affairs. So much of the lawyer's work is done in terms of immediate issues, so many demands are imposed on him by the day-to-day hurly-burly, that it is easy for men outside the profession, and indeed, for some lawyers themselves, to lose sight of the core of knowledge and ministry that renders the law a profession in the real sense. For the same reason, lawyers in their endeavor as professional men to contribute to the formation of public opinion often appear mainly to be engaged in direct short-range action. But it is a fair question whether their long-range influence, as exerted by an Elihu Root or an Oliver Wendell Holmes, is not the greater source of the power which this profession wields in clarifying public thinking on great questions of justice and human rights.

Other professional groups in the population, partly because they inherently are defined more loosely than these three, partly because the knowledge which they administer is more remote from the daily concerns of the people, cannot be traced so clearly in their influence on public thinking. Teachers, for instance, constitute a profession, but it is not so homogeneous as the medical profession, perhaps because it lacks the provisions for indoctrination of neophytes and the formalization of entry into mastership which are characteristic of such organically matured professions as medicine and the clergy. No one would fail to recognize the great influence for good which teachers exert altogether apart from their work of instructing the youth in a particular discipline, yet to trace the operation of that influence is baffling, in large measure because teachers as a professional group have not attained and really do not need to attain the comparatively close-ranked unity and self-regulation which, for example, the legal profession maintains.

ENGINEERING AND SCIENCE AS PROFESSIONS

These last comments are not made for the mere purpose of listing some more professional groups, but rather because they are significant in connection with the question of assumption of professional responsibilities by scientists and engineers. The general question implicit in our review of the dilemma of the professional man now is squarely before us. Natural scientists, physicists and chemists in particular, who in the past have been concerned primarily with the perpetuation and extension of knowledge and so have been more scholars than professional men, now are reaching the status of a profession. Engineers, who have had professional consciousness as a group for a considerable period and have expressed it through their continued efforts to develop an agreed code of ethics, encounter some difficulty over professional status because of their linkage with the economic and industrial structure. Yet I believe it has come to be recognized more widely that science and engineering are professions, even though not all scientists and engineers are professional men.

Why this development? There are many reasons, but for our present purpose we need cite only the most plain and direct of them. The esoteric equations of the mathematician and physicist of but a few years ago, as extended by further research, by applied science, and by technology and engineering, have become a matter on which the future and the fate of mankind depend—the reality of the release of atomic energy. Here, in the dispositions which the nations of the world decide to make in order to control or not to control a vast new force, the scientist perforce is brought out of his laboratory, for sound dispositions capable of assuring just and feasible utilization of this energy for the good of all men cannot hope for realization without his active help. Even if he wished, the physical scientist of today no more can cling to the isolated contemplation of knowledge than a romantic 14-year-old boy can go back to the days of Buffalo Bill. Rather, because of his special competence in a body of knowledge that has come to be a vital issue for the people as a whole, and that means not the people of the United States alone but the people of all the world, the physical scientist is possessed of the authority and must accept the responsibility that mark the professional man as distinguished from the simple scholar.

In passing, let me observe that this last assertion is well substantiated by the fact that in the United States science as a professional calling and scientists as professional men are asking of the people the special consideration and the special position to which none but the professional rightly can lay claim. The legislation by means of which the people of the United States would establish a National Science Foundation insofar as it confers on science and scientists a special relationship to the rest of American life, justified by their disinterested contribution to the whole of American life, marks the coming of age of science as a profession. It is for those of us who are scientists and engineers to realize to the full that sharp and often onerous responsibilities accompany that special relationship.

As we do so, as we undertake to meet the responsibility of professional men to contribute as best they can to the formation of public policy, we encounter the same dilemma that other professional groups have met. It is assured that we shall exert a long-range indirect influence, and that we will pay sincere heed to it. Shall we superpose on it efforts at direct action, and if so, how far shall we go in this direction? There are degrees in direct action, and the crux of the problem is to make sure that the desire to help speed a social advance shall not carry us to a point in direct action which in the end will mean a net loss to society. How far in direct action can the scientist as a professional man go without unduly hazarding the disinterestedness which makes him a valuable member of the community? The classic divergence of views of government in the days of Alexander Hamilton and Thomas Jefferson is recalled in the implications of this question. As I see it, for all the value that direct action often has to recommend it, direct action, in a social and economic structure so complex and so intricately cross-connected as that in the United States today, can be very dangerous. I do not judge, I do not evaluate the issues in question, but I do point out that within recent months the United States has been brought to the very verge of impotence and frustration by the extreme direct action of a single small group in its population. Enthusiasts for direct action on any issue must remember this, and must balance possible ill effects against the supposed worth of speed—if direct action really does produce speed.

Science as a profession of course as yet has not reached its answer to the dilemma; it is in the process of doing so. Some scientists, some engineers, have turned to direct action involving at times the extreme techniques and tactics of the pressure group, conscious, one hopes, of the hazard they run of becoming ex-scientists or ex-engineers, as a result. It is too early yet to judge of the effectiveness of these groups. Some scientists, as witness those in the board of consultants who drew the notable state paper known as the Lilienthal report, have collaborated ably as professional men in laying bases for public policy, thus engaging in tempered direct action within the frame of government. Many, probably all, other scientists and engineers who are undecided as yet, are searching their minds as never before, in the sincere effort to determine what their duty is, and how best to perform it.

VALUE OF SELF-ANALYSIS

Thus we are brought back to the position of the sage who, in his insistence on definition and clear statement, was indeed the forerunner of the rigor and the discipline which scientists and engineers must strive for. We are brought back to Socrates, and to his declaration that an unexamined life is not worth living. Though in this swift-paced age the time is short, I welcome the fact that this is so, that the occasion for true analysis is on us, for I am sure that the end result cannot but be good. Thus far, I have spoken of science, and professions, and the professional man's dilemma, almost entirely in terms of the United States. Now let me go beyond that, for the full implications of the question, as concerns science, extend beyond national boundaries even though a sound solution of it will mean the greatest good at home.

In the self-scrutiny to which we are brought by the inescapable force of events, scientists and engineers possess, more immediately than any other professional group, two very great strengths. In the first place, their professional activities enrich them as a group with a greater frequency and a greater range of contact and collaboration with men of other nations than are enjoyed by other professions. In the second place, and more importantly, the very nature of the body of knowledge with which they deal knows neither time, nor place, nor nations, nor peoples. Astronomer or zoologist, Briton or Yugoslav, rock-ribbed Republican or Communist, in the face of the elusive and eternal objective truths with which he deals, the man of science is simply that—a scientist. As a profession, then, we have common ground with men of all kinds and conditions, common ground that in these days of the breathtakingly swift juxtaposition of races, creeds, cultures, and political philosophies is of inestimable value as a means toward understanding and mutual confidence. Whatever we do toward furthering meetings on that common ground, toward fortifying and confirming it as a starting point for other meetings by other men, is so much done toward the inculcation of collaboration and concord among the peoples of the earth.

Here is an ethical imperative such as no professional group before this time has had the privilege and the opportunity to meet. As here in the United States we examine the standards of honesty and objectivity which science requires but which our profession has not yet brought together in a self-imposed and self-administered code of ethics, we shall accomplish two great ends. First, we shall clarify and confirm in our own minds what and why we are and how and why we best can share in the forming of the sound public opinion essential to strength and stability. Second, we shall chart the broad reaches of knowledge and determine the seamarks of sure intellectual and ethical principles which, because they are common to us as scientists, will be recognized by scientists everywhere as common to them also. Thus, in the full stature of a matured profession, men of science throughout the world can join in meeting the responsibility stemming from their ministry to the people and can do their full share in the formation of the enlightened world opinion which must be developed for peace among the nations to be assured.

The Sign of Reactive Power

AN AIEE COMMITTEE REPORT

By arbitrary definition inductive reactive power is considered negative. Ample justification seems to exist for changing the sign of reactive power, and the steps already taken in that direction are reflected here. Comments from the readers should be addressed to the secretary, AIEE Standards committee, 33 West 39th Street, New York 18, N. Y.

IN RECENT YEARS the concept of reactive power and its flow in electric circuits has become an extremely useful concept in power system analysis and operation. To provide definiteness in technical discussions, in analytical and network calculator investigations, and in recording system power readings for dispatching and similar operating purposes, it is highly desirable that the sign associated with the reactive power under definite circuit conditions should be standardized and that practice generally should agree with the standard. As explained here, there are two possible conventions for the choice of sign for reactive power, both of which have about equal technical validity. One of these has been adopted as standard by the American Standards Association and incorporated in the "American Standard Definitions of Electrical Terms," ASA C-42, in definition 05.21.050. However, as the concept of reactive power became more widely used, its users have become more thoroughly convinced that the opposite sign was preferable, for reasons that are practical rather than technical. At present, therefore, practice is predominantly the opposite of the standard.

The question is not one of positive direction but of positive concept. To analyze a sinusoidal a-c circuit precisely at any pair of terminals or points of entry it is necessary to assign, definitely or tacitly, an assumed positive direction of current to the circuit and an assumed polarity to the terminals. Then, under either concept, the current is positive when its instantaneous direction is the assumed positive direction, and the voltage is positive when the assumed positive-polarity terminal is instantaneously at a higher potential than the other. With no other assumptions, the instantaneous power is positive when the instantaneous current and voltage are both positive or both negative, and the average real power is positive if the phase angle between the corresponding current vector and voltage vector is less than 90 degrees. However, the assumptions made are insufficient to determine whether the reactive power at the same points of measurement under the same conditions is positive when the voltage vector leads the current vector (by less than 180 degrees) or when the current vector leads the voltage vector. An additional concept or assumption is necessary and unless all users make the same assumption confusion results.

Recognizing that this confusion is undesirable, the Standards committee of the AIEE, acting on a recommendation of the power transmission and distribution committee, in May 1944 appointed a subcommittee to investigate this matter and make suitable recommendations. In June 1945 this subcommittee, by two-thirds vote, recommended that the American Standard Definition 05.21.050 be changed to agree

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This report was prepared by a subcommittee of the AIEE Standards committee, consisting of **R. C. Bergvall** (M '41, *chairman*), assistant to the vice-president, engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa.; **W. A. Lewis** (F '45, *acting chairman*), consultant in electrical engineering, Armour Research Foundation, Chicago, Ill.; **W. R. Brownlee** (M '38), investigations division, Commonwealth and Southern Corporation, Jackson, Mich.; **S. B. Crary** (M '38), central station engineering division, General Electric Company, Schenectady, N. Y.; **H. L. Curtis** (F '26), physicist, National Bureau of Standards, Washington, D. C.; **A. E. Knowlton** (F '30), associate editor, *Electrical World*, McGraw-Hill Publishing Company, New York, N. Y.; **W. C. Sealey** (M '38), engineer in charge, transformer division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.; **H. K. Sels** (F '45), transmission and substation engineer, Public Service Electric and Gas Company, Newark, N. J.; **H. M. Trueblood** (F '40), protection development engineer, transmission engineering department, Bell Telephone Laboratories, New York, N. Y.; **S. H. Wright** (M '34), electrical engineer, Ebasco Services, Inc., New York, N. Y.

with existing widespread practice, and that the standard sign for reactive power be reversed. The Standards committee accepted the report and referred it for further action to the American Standards Association. The appropriate ASA committee, C-42, on standard definitions of electrical terms at present is not organized to handle such matters. While this ASA committee is being reorganized, the present article is being published, to solicit general discussion, so that, if possible, the necessity for further delay may be obviated when the reorganization of ASA committee C-42 is completed.

THE CONCEPT OF REACTIVE POWER

Series Circuit. Figure 1 shows a series inductive circuit of resistance R and inductive reactance X, carrying a sinusoidal current. On a conventional impedance diagram, R is drawn horizontal and X vertically upward, as shown in Figure 2*a*. In complex-quantity notation, the impedance $\boldsymbol{Z}$ is

$$\boldsymbol{Z}=R+jX \tag{1}$$

The corresponding voltage and current vectors, $\boldsymbol{V}$ and $\boldsymbol{I}$, are shown in Figure 2*b*, with the voltage leading by the angle ϕ. The average real power, P, absorbed by this circuit is given by the familiar relation

$$P=RI^2 \tag{2}$$

where I is the magnitude of the current vector $\boldsymbol{I}$. This quantity is, of course, the average instantaneous power, where the instantaneous power is itself a double-frequency quantity.

By analogous reasoning, the reactive power may be *defined* as

$$Q=XI^2 \tag{3}$$

and it is measured in vars, or multiple units, as kilovars, megavars, and so forth.

For many purposes it is convenient to plot both the real power, P, and the reactive power, Q, on the same diagram. This may be done by plotting real power horizontally and positive reactive power vertically upward, as in Figure 3, in which the real power is represented by P and the reactive power by jQ.

For convenience, the vector sum of these two quantities, when the current and voltage are sinusoidal, is defined as the vector power, $\boldsymbol{S}$, so that

$$\begin{aligned}\boldsymbol{S}&=P+jQ\\&=RI^2+jXI^2\\&=(R+jX)I^2\\&=\boldsymbol{Z}I^2\end{aligned} \tag{4}$$

In accordance with this concept, vector power is the product of the impedance, treated as a complex quantity, and the square of (the magnitude of) the current.

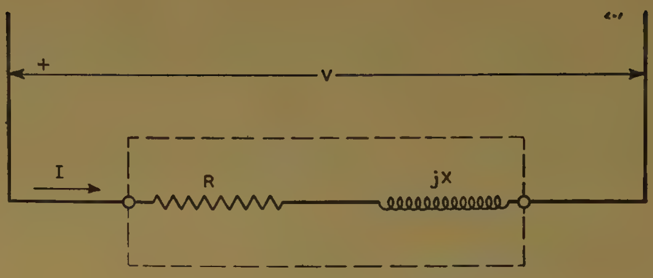

Figure 1. Series circuit

It is well known that the real power, P, may be expressed also as

$$\begin{aligned}P&=VI\cos\phi\\&=VI\cos(\alpha-\beta)\end{aligned} \tag{5}$$

and the reactive power as

$$\begin{aligned}Q&=VI\sin\phi\\&=VI\sin(\alpha-\beta)\end{aligned} \tag{6}$$

In order that Q in equation 6 may agree with Q in equation 3, it is necessary that ϕ in Figure 2*b* be taken as positive. That is, the angle ϕ must be defined as the (positive) angle by which the voltage $\boldsymbol{V}$ leads the current $\boldsymbol{I}$, or

$$\phi=\alpha-\beta \tag{7}$$

In terms of equations 5 and 6, the vector power becomes

$$\begin{aligned}\boldsymbol{S}=P+jQ&=VI(\cos\phi+j\sin\phi)\\&=VI[\cos(\alpha-\beta)+j\sin(\alpha-\beta)]\\&=VI\epsilon^{j\phi}=V\epsilon^{j\alpha}I\epsilon^{-j\beta}\end{aligned} \tag{8}$$

The voltage and current vectors are given by

$$\begin{aligned}\boldsymbol{V}&=V\epsilon^{j\alpha}\\\boldsymbol{I}&=I\epsilon^{j\beta}\end{aligned} \tag{9}$$

The conjugate of the current vector is, by definition, a vector having the same magnitude but the opposite phase angle. Therefore, the conjugate of the current vector is

$$\text{conj }\boldsymbol{I}=I\epsilon^{-j\beta} \tag{10}$$

Substituting $\boldsymbol{V}$ and conjugate $\boldsymbol{I}$ in equation 8 shows that the vector power may also be expressed as

$$\boldsymbol{S}=P+jQ=\boldsymbol{V}\text{ conj }\boldsymbol{I} \tag{11}$$

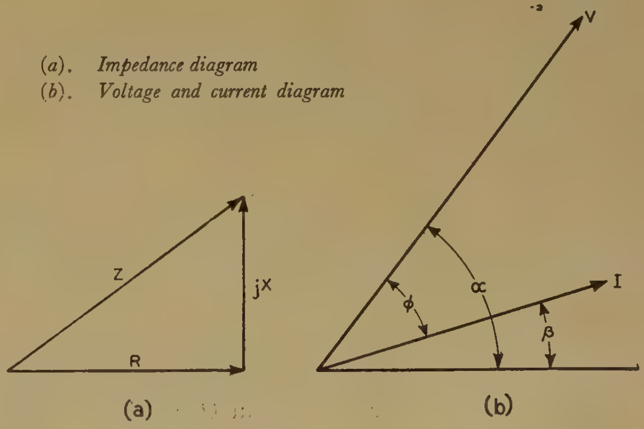
(*a*). *Impedance diagram*
(*b*). *Voltage and current diagram*
Z
jX
R
V
I
φ
α
β
(a)
(b)

Figure 2. Impedance and voltage–current relations for Figure 1

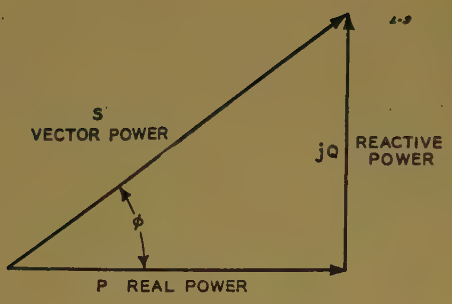

Figure 3. Power diagram for Figure 1

Q taken as positive for inductive reactive power

or, stated in words, the vector power is equal to the product of the voltage vector and the conjugate of the current vector. The real part of the vector power is the real power and the imaginary part is the reactive power.

Parallel Circuit. If the resistance and reactance of Figure 1 were enclosed in a box so that only the terminals were accessible, the circuit could be represented equally well by a resistance and reactance of suitable values connected in parallel, as shown in Figure 4. By measurements at the normal frequency, made at the terminals only, it is not possible to determine whether the circuit is a series or parallel circuit. For equivalence, the parallel circuit must have an admittance $\boldsymbol{Y}$ given by

$$\begin{aligned}\boldsymbol{Y} &= G+jB\\ &= \frac{1}{\boldsymbol{Z}}\\ &= \frac{1}{R+jX}\\ &= \frac{R-jX}{R^2+X^2} \qquad (12)\end{aligned}$$

from which

$$\begin{aligned}G &= \frac{R}{R^2+X^2}\\ B &= -\frac{X}{R^2+X^2} \qquad (13)\end{aligned}$$

That is, if the reactance, X, is positive, as for an inductive circuit, the corresponding susceptance, B, must be negative. Therefore, on an admittance diagram, G is plotted horizontally and B vertically downward, as shown in Figure 5. The voltage and current vectors again are given by Figure 2*b*.

It is well known that the real power P for a parallel circuit is given by

$$P = GV^2 \qquad (14)$$

By analogous reasoning, the reactive power may be *defined* as

$$Q = BV^2 \qquad (15)$$

If these values of P and Q are plotted on a power diagram, P will be horizontal, but Q will be vertically *downward*, as shown in Figure 6, because its value is negative when B is negative in equation 15.

That is, if reactive power is *defined* on the basis of a series circuit, by analogy with the impedance, using equation 3, its numerical value will have the opposite sign to what it would be if reactive power were *defined*, by analogy with the admittance, by equation 15. The real power, it may be noticed, is the same in either case.

The vector power, taken as the vector sum of the real and reactive power quantities in Figure 6, will be

$$\begin{aligned}\boldsymbol{S} &= P+jQ\\ &= GV^2+jBV^2\\ &= (G+jB)V^2\\ &= \boldsymbol{Y}V^2 \qquad (16)\end{aligned}$$

With the definition based upon a parallel circuit, vector power is the product of the admittance, treated as a complex quantity, and the square of (the magnitude of) the voltage.

In terms of V and I, P and Q now become

$$\begin{aligned}P &= VI\cos\phi = VI\cos(\beta-\alpha)\\ Q &= VI\sin\phi = VI\sin(\beta-\alpha) \qquad (17)\end{aligned}$$

In order that Q in equation 17 may agree with Q in equation 15 it is now necessary that ϕ in Figure 2*b* be taken as negative. That is, the angle ϕ must be defined as the angle by which the current $\boldsymbol{I}$ leads the voltage $\boldsymbol{V}$, and is negative when the voltage leads. In other words,

$$\phi = \beta - \alpha \qquad (18)$$

which is the opposite of equation 7.

In terms of equation 17, the vector power becomes

$$\begin{aligned}\boldsymbol{S} &= P+jQ = VI[\cos(\beta-\alpha)+j\sin(\beta-\alpha)]\\ &= V\epsilon^{-j\alpha}I\epsilon^{j\beta} = \text{conj}\,\boldsymbol{VI} \qquad (19)\end{aligned}$$

where

$$\text{conj}\,\boldsymbol{V} = V\epsilon^{-j\alpha} \qquad (20)$$

is the conjugate of the voltage vector. With the definition of reactive power based on a parallel circuit, the vector power is equal to the product of the conjugate of the voltage vector and the current vector. This is the opposite, that is, the conjugate of equation 11.

ARBITRARY CHOICE OF SIGN OF REACTIVE POWER

The two preceding sections have demonstrated that there are two technically valid choices for the definition

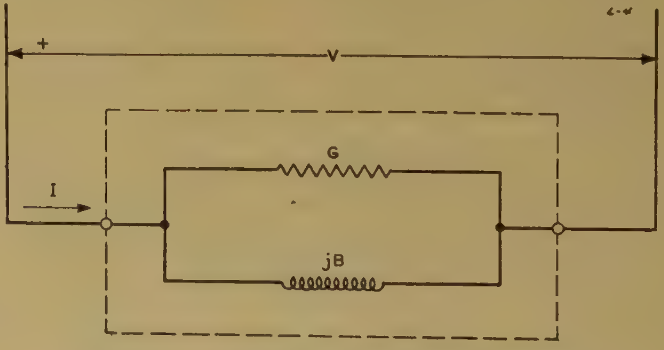

Figure 4. Parallel circuit equivalent of Figure 1

of reactive power, one based on a series circuit and an analogy with impedance and the other based on a parallel circuit and an analogy with admittance. If the first choice is selected, the reactive power absorbed by an inductive load is *positive;* if the second choice is selected, the reactive power absorbed by an inductive load is *negative.* The first choice is now recommended by the subcommittee, because of practical considerations, and corresponds to the series-circuit analogy. The second choice is the existing standard. From the standpoint of the preceding analysis, the choice is arbitrary, as there is no means of stating positively that the series circuit is more fundamental than the parallel circuit, or vice versa.

Either definition can be used consistently for either series or parallel circuits, but the analogy between the vector power diagram and the impedance and admittance diagrams cannot be maintained for both cases. If the first convention is chosen, the vector power diagram is similar to the impedance diagram but is similar to the *image* of the admittance diagram. The reactive power, Q, will have the opposite sign to B and will be plotted in the opposite direction. If the second convention is chosen, the vector power diagram will be similar to the admittance diagram, but will be similar to the *image* of the impedance diagram.

The present ASA Standard published in 1942 followed the results of a ballot taken about 13 years ago to determine whether the vector representing inductive reactive power should be drawn upward or downward. At that time there was little preponderance in favor of either standard, and the decision was based largely upon the fact that power system loads consist of many individual loads connected in parallel. For power purposes, a choice based on the parallel circuit then seemed the more rational. The present recommendation of the subcommittee is that inductive reactive power be defined as a positive quantity, corresponding to the series-circuit analogy, for the practical reasons discussed in the next section.

PRACTICAL CONSIDERATIONS IN SELECTING THE SIGN OF REACTIVE POWER

In spite of the ASA definition referred to, the preponderant use of the concept of reactive power has favored the first concept in which the reactive power absorbed by an inductive load is positive. In the following discussion, therefore, the advantages of the first concept, from a practical viewpoint, will be stated.

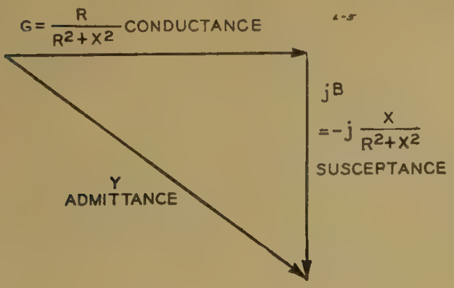

Figure 5. Admittance diagram for the circuits of Figures 1 and 4

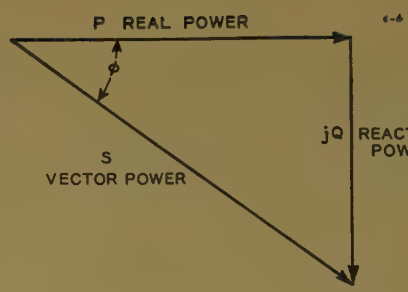

Figure 6. Power diagram for Figure 4

Q taken as negative for inductive reactive power

1. Most loads are inductive and absorb positive real power (kilowatts) and inductive reactive power (kilovars) *from* the system.

With the proposed definition, the reactive power of the most common loads will be positive, and both kilowatt-hour and kilovar-hour meters will normally rotate in the positive direction.

2. Rate structures commonly are based on charging for the integrated use of real and inductive reactive power, both considered as positive quantities.

With inductive reactive power positive, the customer is charged for the integral of the reactive power or the kilovar-hours which he consumes. With the opposite convention he is charged for the kilovar-hours which he supplies to the power system, and the more he supplies, the more he is charged.

3. Inductive reactive power causes a voltage drop in the direction of its "flow" through an inductive circuit, just as real power causes a voltage drop in its direction of flow through a resistive circuit.

With inductive reactive power as positive, positive real power flow and positive reactive power flow both produce voltage drops in the direction of flow in normal circuits. With the opposite convention, positive reactive power flow produces a voltage rise in the direction of flow.

4. Both real power and inductive reactive power are "lost" in the process of transmission.

With inductive reactive power as positive, both real and reactive power "losses" are positive in normal circuits.

5. Increasing the prime mover input to a synchronous generator increases its real power output. Increasing the field excitation increases the inductive reactive power output.

With inductive reactive power as positive, a positive increase in both real and reactive power output will accompany an increase in the corresponding input quantity.

6. Generator wattmeter and varmeter indications will be better co-ordinated.

With inductive reactive power as positive, varmeters should be designed to read upscale (to the right) with increasing inductive reactive power, instead of downscale (to the left). Then with normal load increases, both wattmeters and varmeters will read farther to the right.

To obtain the advantages described under reasons 1, 3, 4, and 5, the great majority of a-c network calculator studies of power systems have been made with inductive reactive power treated as positive.

All of the reasons enumerated strongly favor the recommended change in the Standard. No corresponding reasons were found favoring retention of the present Standard. Although all of these reasons are based upon the normal operation of power systems, and do not include specifically other applicatons, a survey of the fields of electronics, communication, and radio failed to reveal any extensive use of the concept of reactive power in these fields. Such practice as was found did not particularly favor either convention, as either, if definitely understood, could be used equally well.

The standard convention was adopted in 1935, was followed by ASA Standard C-42 in 1942, and was adopted internationally by the International Electrotechnical Commission. Some opposition to the proposed change has been voiced by two of ten committee members because of the international sanction given the present standard. However, the survey by the subcommittee showed that the standard was not being widely followed, and that there was little probability that the preponderant users would give up the definite advantages of their present practice for the nebulous advantages of using an unwieldy standard. No workable compromise which would allow the standard to remain unaltered and would at the same time meet the objections to it could be found. Therefore the subcommittee, with the concurrence of the AIEE Standards committee, recommends that the American Standards Association, acting for the United States, adopt the change and recommend that other nations do likewise. In no other way, in the opinion of the subcommittee, can the standard, as it is intended to do, express the meaning of the term "reactive power" as it generally is employed in electrical engineering.

Discussion and comment on the recommendation are solicited. Letters should be addressed to the secretary, AIEE Standards committee, 33 West 39th Street, New York 18, N. Y.

Radio Relays for Telegraphy

F. B. BRAMHALL
FELLOW AIEE

With the opening of the superhigh frequency spectrum, the American telegraph industry now finds it economically possible to utilize radio relaying and still attain the necessary high degree of circuit stability and continuity. However, radio power is not yet practical for smaller systems but should be reserved for routes with relatively heavy traffic loads such as the proposed New York–Washington–Pittsburgh network.

THE DOMESTIC telegraph industry of the United States has come to expect a degree of circuit stability and continuity which, until now, has been economically quite impossible for radio to attain. The opening of the superhigh frequency spectrum under the impetus of military necessity for radio locators has changed this picture however. The highly directional antennas of practical size available for frequencies from 3,000 megacycles up, and the complete absence of natural and man-made noises in this region, make it possible today to obtain with a fraction of a watt of radio power the results formerly achieved with 100 kw.

The ability to beam the transmitted radio energy in a very narrow cone, and the geometric line-of-sight behavior of the propagation, permit the establishment of a comprehensive network with an absolute minimum number of radio frequency channels. In fact, as many as eight separate circuits can be operated into a heavy traffic center on a single frequency. Noninterfering reception can be accomplished on the same frequency in every 45 degrees of the compass. Likewise, a second frequency may be used for transmission in the opposite direction, if the beam directions are separated by 45 degrees. It is perhaps ironical, but certainly fortunate, that the same frequency register which admits of highly directional beams, at the moment seems to be the one region of the spectrum which will not become overcrowded in the immediate future. These considerations are among those which induced the Western Union Telegraph Company to prepare elaborate plans for handling much of its trunkline traffic on a comprehensive radio relay network. A first step in the company's extensive postwar improvement program is a triangular radio relay network with terminals at New York, N. Y., Washington, D. C., and Pittsburgh, Pa. Construction permits already have been granted by the Federal Communications Commission for the 20 or so stations required in this system. Station sites have been selected

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Essential substance of a paper presented at the AIEE South West District meeting, San Antonio, Tex., April 16–18, 1946.

F. B. Bramhall is transmission research engineer, The Western Union Telegraph Company, New York, N. Y.

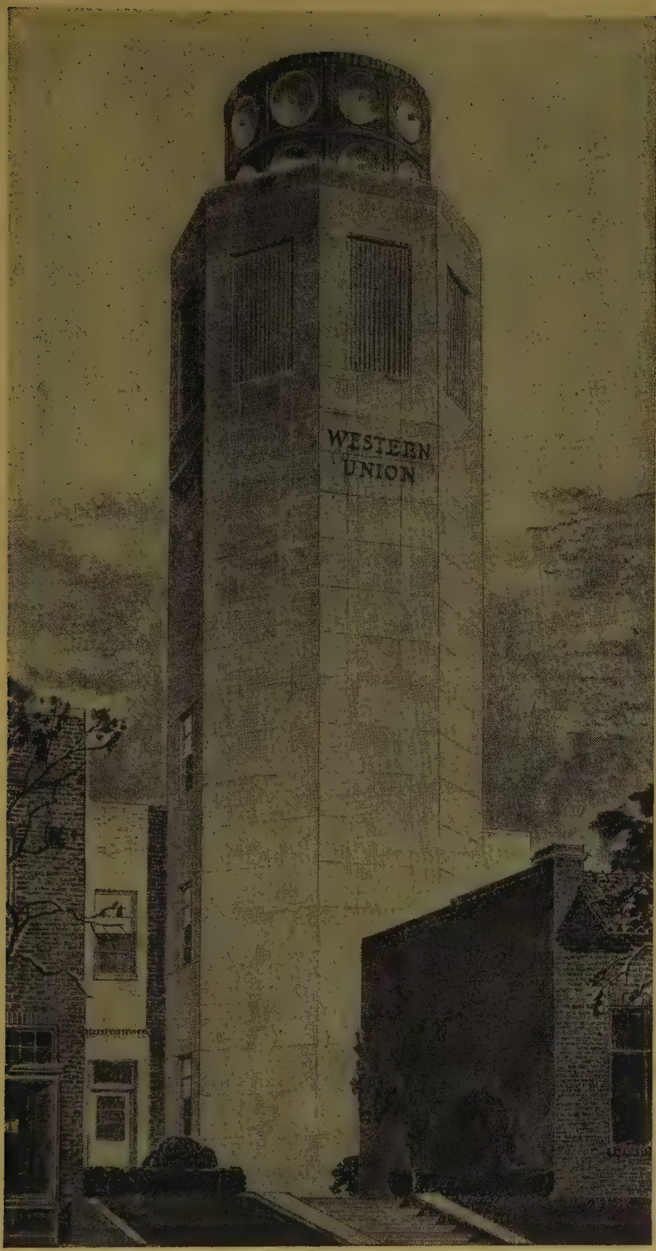

Figure 1. Design for suburban relay terminal tower for large city

and purchased or leased, building construction is already under way, and equipment commitments have been made. The derived facilities will be used for all types of record communication circuits, including multiplex, facsimile, teleprinter, and various other business aids.

RELAY STATIONS

Unattended radio relay stations, spaced from 20 to 50 miles apart, are projected between many of the major heavy traffic centers. Experimental work done during the past several months indicates that a geometric line-of-sight path between the transmitting radiator and the receiving collector is mandatory. In open country, therefore, the accessibility of elevated relay station sites, the availability of commercial electric power, and like factors, determine the repeater spacing. Propagation studies, though nowhere nearly adequate scientifically, already have indicated the desirability of keeping the transmission path clear, not only of the ground, but of trees and buildings throughout the entire span. In the eastern mountain section of the United States, these considerations led to open country spacings which average about 40 miles per hop. In this type of country, of course, advantage is taken of relatively high ground but, generally speaking, the highest mountain tops are avoided. Near certain large centers of population, short hops sometimes result from the fact that such cities frequently are located in relative depressions of topography.

The experience on which the present conclusions are based was gained mainly in the region of 4,000 megacycles. In this region, fog, rain, snow, and other weather phenomena most commonly met cause no serious change in signal attenuation. Throughout all seasons of the year, the phenomenon called "slow fading" is encountered, presumably resulting from a bending of the beam caused by either temperature or humidity gradients from the earth's surface upward. The magnitude of this fading over a 30-mile span can be said to be in the neighborhood of 30 decibels. At certain seasons of the year, a phenomenon called "rapid fading" causes the received signal to fluctuate wildly in a manner which definitely suggests the multipath cancellation well known in longer wave radio transmission, and attributed to ionized layers in the upper atmosphere. It seems quite obvious that the reflections which cause multipath fading in the superhigh frequency region do not come from higher reaches of the atmosphere. A sufficient reason for this conclusion is the extreme directivity of the receiving antenna, its effective beam being six degrees in total width. The most logical present postulate is that at times of perfect atmospheric quiet, extremely flat and continuous stratification of either temperature or humidity, probably both, are responsible. The rare conditions under which multipath cancellation of this type occurs seem to be most prevalent in the early morning hours of the early summer months. Experience to date indicates that little difficulty is met in overcoming the slow fading phenomenon by conventional methods, and that the rapid fading phenomenon can be overcome, as in long wave transmission, by diversity reception.

RADIO RELAYING VERSUS WIRE LINES

The economies of radio relaying in competition with wire lines indicate that the former medium is justified only for relatively heavy traffic loads. For a single telegraph printer circuit, radio is quite out of the question. Even for several score of printer circuits, it is

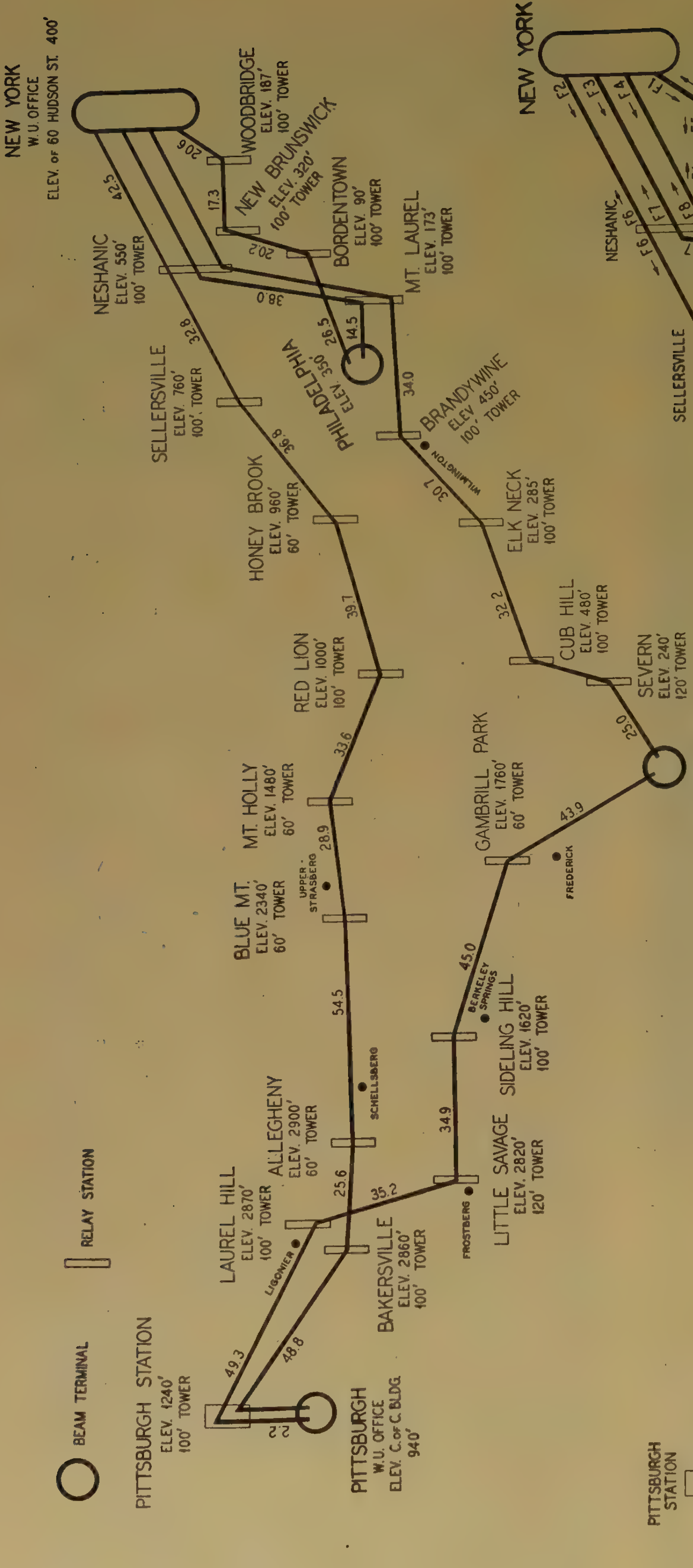

Figure 2. Location and elevation of towers in radio relay system between New York, Washington, and Pittsburgh

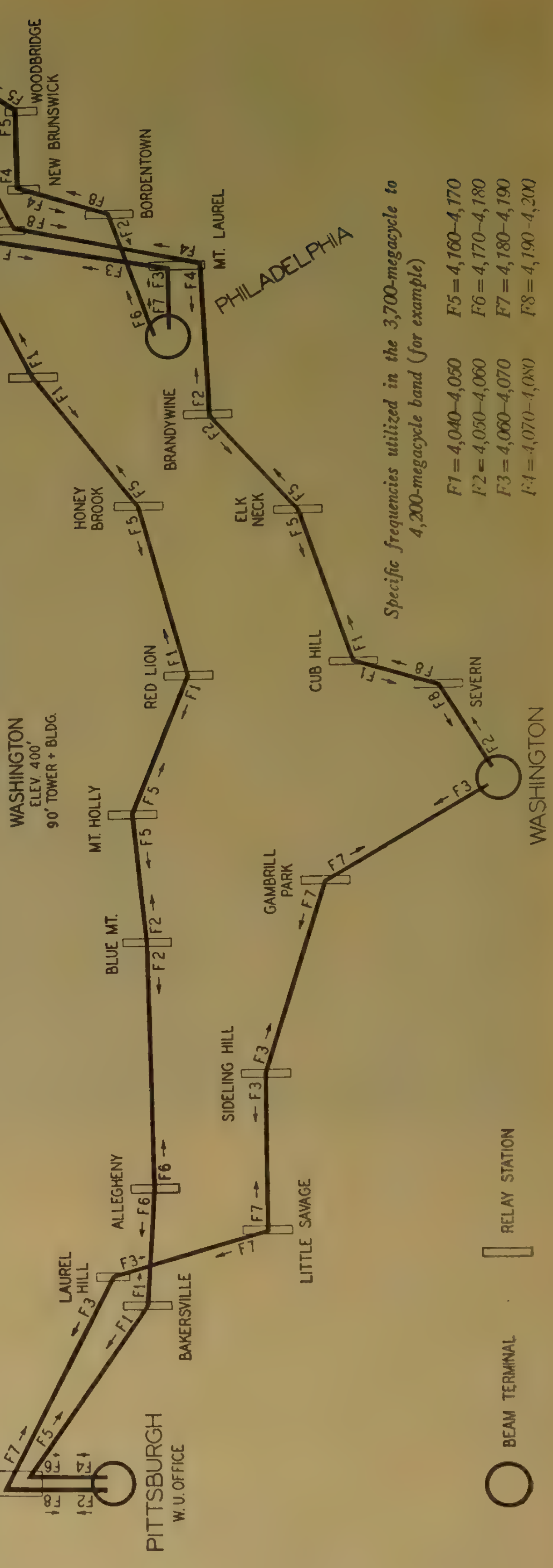

Figure 3. Chart of New York–Washington–Pittsburgh radio relay system showing typical transmitter frequency assignments

certainly of very doubtful economy. For several hundred, the studies indicate that the kind of equipment and the grade of maintenance, necessitated by the high continuity standards to be met, can be justified. Considerations of this nature have led to the adoption of a useful "audio" channel width of 150 kc. This amount of "audio" spectrum is capable of division into 1,080 teleprinter operating circuits.

The term "audio" is used in this article, not in any literal sense, but only to indicate the analogy between the present development and the most familiar radio telephone practice. One of the outstanding technical features of the present development is the ability of the radio modulation system to handle such a great number of independent signaling frequencies without the production of a prohibitive amount of interchannel interference. The final superhigh frequency radio carrier is, of course, frequency modulated. The maximum frequency swing, conforming generally to accepted practices, is in the neighborhood of ±2.0 megacycles. The available sources of superhigh frequencies lend themselves most readily to frequency modulation, and limiting amplifiers are extremely effective and simple devices for the mitigation of the effects of fading. These and several other factors, centered around the extreme requirements for "audio" band linearity, led naturally to the choice of frequency modulation. Present techniques for the measurement, generation, and control of frequency in the superhigh frequencies region leave something to be desired in the way of radio spectrum economy. The system employed requires that the nominal radio carriers be separated by not less than ten megacycles in the 4,000-megacycle region. Proportionally greater channel separation will be needed at higher frequencies.

As yet, too little data are at hand to permit even an intelligent guess as to whether the 4,000-megacycle region is the proper location for a telegraph radio relaying network. Perhaps some of the fading phenomena observed will exhibit different characteristics in another region. It is known, of course, that as the frequency is increased on up toward 30,000 megacycles, moisture particles in the atmosphere can increase the path attenuation seriously.

THE CARRIER SYSTEM

The carrier system developed to permit so great a number of separate telegraph communication circuits to be stacked in a 150-kc band is unique even to the wire communication art. It is, of course, a single sideband system, resulting finally, at the "audio" input to the radio equipment, in one independent carrier frequency for each derived telegraph channel. Telegraph channels are grouped by the single sideband modulation equipment, each group containing eight telegraph carriers spaced 150 cycles apart, and capable of operation by frequency modulation at 66 bauds (33 cycles per second). The translating system, by means of which eight separate voice frequencies ranging from 525 cycles to 1,575 cycles are stacked one above the other up to 150 kc, differs from the conventional translating systems used in carrier telephony in that individual voice band filters are not required. Hence the method of translation avoids the wasteful guard bands necessary in the conventional technique and permits an economy of spectrum utilization previously obtainable only through the use of relatively expensive crystal filters.

Frequency modulation of the primary "audio" telegraph carrier is a technique adopted by the Western Union company several years back, and is in very extensive use in the company's wire communication network. Using a deviation ratio of one, it affords a degree of freedom from the distortion caused by level changes and extraneous disturbances not possible in amplitude-modulated telegraphy. The contemplation of frequency modulation on a telegraph channel, which uses discriminators sensitive to a frequency drift of even two cycles, brings a realization of the frequency accuracy

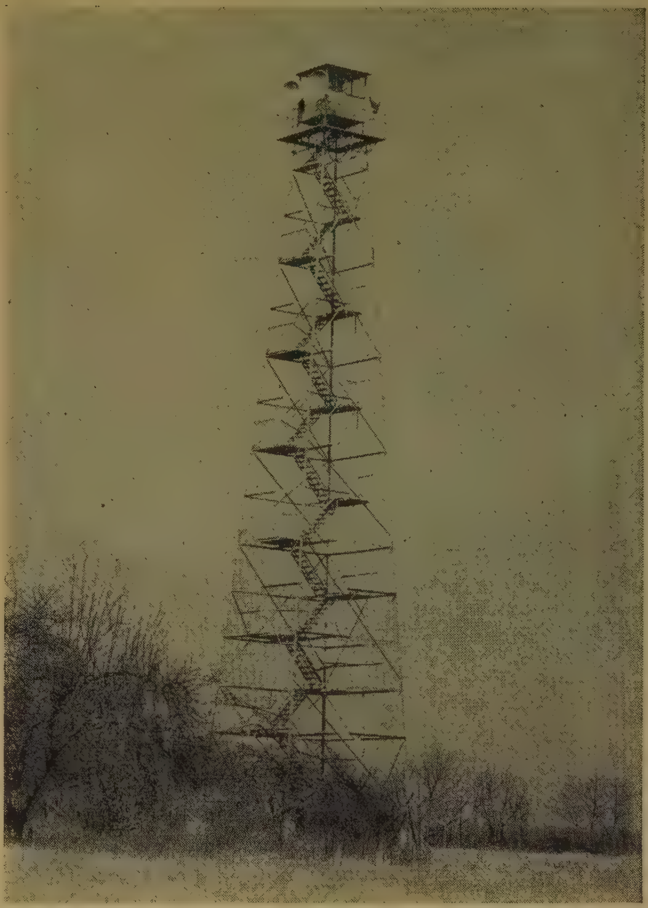

Figure 4. Relay repeater tower of New York–Philadelphia experimental system

required in the oscillators of the 150-kc translating equipment. This problem is solved through the use of an accurate temperature-controlled reference crystal.

RADIO TERMINALS

Serving only the heavily loaded trunk routes, radio system terminals generally are located in business centers of large cities where adequate elevation is secured for antennas on tall office buildings. In installations of this type now under construction, the antennas are mounted on a suitable frame on the roof or inside a penthouse. Radio equipment, back to the "audio" band circuit, is located either in the penthouse or in nearby space on the floor directly underneath. Carrier translating equipment for the first breakdown to 3-kc voice bands is installed in equipment rooms already established for wire carrier operation.

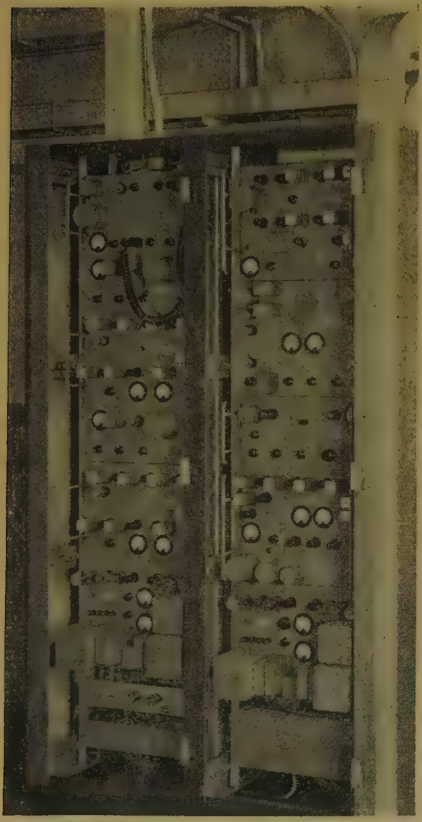

Figure 5. Two-way radio equipment at terminal stations

Another form of radio terminal installation is that located in the restricted suburban outskirts of Washington, D. C., where a rather elaborate monolith type of structure houses the antennas on top. The radio equipment is on an upper floor, the carrier translating equipment, reserve power plants, and facilities for a 24-hour staff of attendants are in the base of the tower and in an adjacent building. In this type of installation, the 3-kc voice bands are carried to the central telegraph office in the heart of the city on underground cable pairs. Various other terminal conditions are encountered, one in which adequate space for the voice band translating equipment is not obtainable at the radio site. In this case, the 150-kc band is carried to the central telegraph office with a mile or more of coaxial cable. It will be understood that terminals of the type discussed generally do not appear as single units, inasmuch as there are alternate routes and other connecting radio circuits radiating from one central location.

At the repeater stations, an open steel tower of considerable rigidity mounts the antennas in a small penthouse. At these stations, a final radio stage on the outgoing side and the initial amplifier on the incoming side are mounted within the penthouse close to the antennas. All other equipment is housed in a rugged building at the base of the tower. This building generally is supplied with commercial power; it has overnight accommodations for a visiting attendant, and a reserve power plant in addition to the radio equipment itself. To facilitate maintenance, automatic switching functions and alarms will be installed at all unattended stations. To one or both terminals of a chain of relay stations, indications of radio equipment and power supply conditions will be conveyed over the radio carrier itself, quite independent of whether the system is carrying live traffic loads or not. Furthermore without disturbance to an operating system, a visiting maintenance man may converse by telephone with other stations in the chains and with the terminals. Plans call for strategically located maintenance men to cover a segment of the chain by automobile, caring for three or more stations. With the automobile will go certain less critical spare equipment components while other spare parts and test gear will be kept at each station. For the most part, equipment servicing repairs will be made at the attendant's headquarters.

RESULTS

By materially reducing circuit interruptions resulting from storms, falling trees, and electrical disturbances, the radio relay system is expected to improve the quality, dependability, and speed of telegraph service provided to the public. From an initial trial installation with a 3-link system from New York to Philadelphia a little more than a year ago, much progress in the development of this service has been made. Credit for adapting what were essentially radar techniques to a vital communication need is due the engineers of the Victor division of the Radio Corporation of America, while responsibility for the application of the medium to the exacting requirements of the industry was assumed by engineers of the Western Union company. These engineers have developed the high capacity carrier system, which makes the new medium an economic practicability. Activities are already well under way for extension of a network well beyond the New York–Washington–Pittsburgh triangle previously mentioned.

Human Progress

C. T. WELLER
MEMBER AIEE

THE halfway mark of the 20th century is still ahead, yet so far there have been two major wars and a third is entirely possible. The human traits responsible for the wars and for the ensuing turmoil are evil enough, but some of the behavior, such as the killing and torturing of the helpless, is on the animal level. Although such traits and behavior were characteristic of large groups in enemy countries they were not restricted to them, so it might be concluded that human progress is stalled if it is not actually in reverse. Before accepting such a pessimistic view it might be well to look back into the past.

This earth, which seems so large to us, is only a tiny part of a universe so immense that its dimensions, if known, would be almost beyond comprehension. Yet the earth may be the only place in all that vast expanse where life such as ours exists. It is estimated that the age of the earth is nearly two billion years and that man has occupied it for at least 500,000 years. Both of these estimates are comparatively new. Many can recall when it was believed that man's sojourn on the earth did not exceed 10,000 years, and even that a definite date could be assigned to his advent.

It required the discovery of radium and the rate of decay of radioactivity in various elements before a reasonable estimate could be made of the age of the earth. It required the discovery of the remains of numerous ancient men and careful appraisal of the formations in which they were found before a reasonable estimate could be made regarding man's occupancy. Some of the most important discoveries have been made in the last half century, which is very recent when compared with the age of the earth.

The largest group of ancient men was discovered, where one might expect it to be in a northern Asiatic climate; in a cave meeting one of the basic human needs—shelter. The cave is located at Chow Kow Tien (or Choukoutien), near Peking, China, and the human remains are known as Peking man. Some of the artifacts were carried off by the Japanese invaders but they were unable to find the carefully hidden bones. Ultimately, all Chow Kow Tien items will be displayed in China; some reproductions now are on display in the United States. It is with reference to such ancient individuals as Peking man that human progress must be evaluated.

Let us visit Peking man in his limestone cave. Perhaps we can slip in while he is away hunting. We find a fire burning and some crude stone tools and bone implements nearby, together with hides, meat, and bones of species of animals now extinct. Otherwise, the cave looks quite bare. His ceaseless struggle for survival apparently has made our host suspicious but we can catch a glimpse of him as he hesitates to approach. He is repulsive to us with his wide, low head, his high brow ridges, and his powerful jaw. He seems to be dominated by fear and unable to speak.

How do we know so much about Peking man? The tools and animal bones were found near his remains, some charred by fire. The skull is most revealing; we can look into that cradle of personality, the brain case. A cast of the brain indicates that the areas associated with intelligent speech were not well developed. Compared with that of modern man the brain is about three-quarter size.

Now suppose that Peking man were to return our visit. He would find our shelters very comfortable because we have learned enough about air conditioning to keep them warm in winter and cool in summer. He would note the windows that keep out cold and heat but admit light. At night, he would appreciate ample artificial light available merely by flipping a switch. It would take considerable time for him to become accustomed to our furniture and clothes but not to our abundant food made possible by canning, refrigeration, and transportation; fruits and vegetables fresh the year around or canned, grains, and meats baked or roasted a predetermined time at a predetermined heat in a modern range. He would understand the uses of some of our household tools but not the lack of weapons. The radio and television set would amaze him. Outdoors, he would see the basic industries of agriculture and lumbering, animal husbandry and fishing, mining and quarrying, and then a bewildering variety of manufacturing, all utilizing power in some form. He could not help but notice that we spew our smoke and soot freely into the air just as he did, nor would he approve our urban habit of sluicing wastes into the nearest stream. On the other hand, he would admire our modes of transportation, especially in air, but also on and under land and sea.

Our visitor probably would be impressed most of all with our assurance, our confidence. He could not know that it resulted from what is perhaps the greatest achievement of science: the assembling of irrefutable evidence that this is a universe of law and order. It operates

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Essential substance of an address broadcast May 8, 1946, from stations WGY and WGFM, Schenectady, N. Y., during the General Electric Science Forum program.

C. T. Weller is an electrical engineer, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y.

with a precision that modern man has the utmost difficulty in matching. If carefully set up, the thousandth, the 100 thousandth, and the millionth experiment give exactly the same result as the first. To the ancient Greeks we owe much of the credit for initiating the change-over from the earlier belief that the universe was subject to the unpredictable whims of super beings, mostly of evil intent. Such beliefs provide fertile soil for the growth of fear and superstition.

Modern beliefs also go beyond science. Many believe that there is purpose in the universe and that life is one manifestation of that purpose. In the maintenance and extension of life the success achieved has been extraordinary. At the apex of an almost infinite number and variety of living things are more than two billion human beings. This mass of humanity is dominated by a single objective: satisfaction. Satisfaction is expressed in ways that have not changed since remote times: gratification of the senses, physical and mental achievement, the quests for certainty, for security, and for power. Under proper control these lead to the highest type of civilization; out of control they lead to individual and national disintegration and to war.

War is not necessarily a bar to progress. War brings out the best of human traits as well as the worst. It stifles basic research but it stimulates applied research and development. War tends to focus attention on human behavior and its causation. Remedial measures are frequently possible and are an important function of international co-operation. A powerful incentive is supplied by the suffering, loss of life, and destruction of wealth in war. Compared with the 19th century, the present extent of co-operation by the United States with foreign nations may come to be considered a milestone of progress. In the domestic field, progress in reducing losses of life and wealth by accident and by fire and in cleaning up the air and streams must be recognized.

This brief survey indicates outstanding progress since Peking man, probably painfully slow at first, and very uneven, but cumulative. If modern man will profit by the lessons of the past, he can face the future with optimism!

The Automatic Sequence Controlled Calculator—III

HOWARD H. AIKEN GRACE M. HOPPER

WHEN A RELATIVELY LARGE number of values, such as constants or random values of a variable, are to be used by the calculator, and further, when these values are to be used in a prescribed order, they may be supplied to the machine via one of the interpolator mechanisms and a perforated paper tape. Such a tape is known as a "value tape" to distinguish it from a functional tape. Mathematically, the operation of reading from a value tape is the equivalent of zero order interpolation. In order to increase the flexibility of the interpolators when used in this manner, three sequence codes have been assigned to each interpolator mechanism. These require that the tape be stepped forward, stepped back, and that the sensing pins read from the tape.

THE CARD FEEDS

Other means of supplying data to the calculator are the two card feeds shown in Figure 1. These employ standard tabulating machine cards and have three advantages over the value tape. First, inasmuch as the tabulating machines are standardized highly, the cards permit the interchange of data from one computation laboratory to another. Second, the devices required in the manual preparation of the cards have been developed to a high degree of perfection. Third, the calculator itself is equipped with a card punching mechanism.

The disadvantage of punched cards as compared with a value tape lies in the fact that the card feeds must accept the cards in the order in which the deck is stacked. No provision is made for retrieving a card once it has passed through the feed. Hence, a second use of the value punched in a card requires the intervention of the machine attendant. When punched cards and value tapes are being used, the coding must be arranged to synchronize their reading units with the main control tape. This implies that suitable operating instructions must be prepared to insure that cards and value tapes are inserted in the calculator properly.

A control is provided on each card feed to stop the calculator when the cards are exhausted or jammed. The quantities in the cards are read into the bus through plugging and therefore may be shifted to conform with the operating decimal position. This is not true, however, of value tapes.

With this issue is concluded a 3-part article describing the automatic sequence controlled calculator developed to carry out any selected sequence of the five fundamental operations of arithmetic. Part III discusses the preparation and planning of the sequence control tapes.

Occasionally a problem is so voluminous as to tax the facilities of the calculator. In such cases, the main control tapes are designed so that the computation may proceed part way, the intermediate results may be punched into cards, and the cards later fed into the calculator for further computation under the direction of a second main control tape.

The card feeds and interpolator mechanisms, together with the switches described previously, represent the means by which numbers may be introduced into the calculator as a basis for computation. For recording computed results, two methods are available: the card punch mentioned in the previous paragraph and two automatic typewriters, Figure 1.

THE "PRINT" AND "PUNCH" COUNTERS

The printing and punching of numbers are accomplished with the aid of registers known as the "print" and "punch" counters together with special circuits designed to control the recording devices. The print and punch counters (Figure 2) are equipped with in- and out-relays and complete carry circuits so that they function as standard storage counters in addition to performing their special purposes.

The controls of the typewriters are very flexible with respect to the number of digits printed, their spacing, columnar position, and line spacing. The computed results may be reproduced photographically directly from the typewritten sheets. This avoids the possibility of error due to copying, inherent in most computational procedures. In order to avoid the loss of computed results, the card punch is equipped with a stop control which prevents read-in to the punch counter, stops the calculator, and lights a red signal light in the event that a blank card is not in the proper punching position at the time the sequence control tape dictates the punching operation.

Not all problems imposed on the calculator require the use of punched cards. Hence, a manual keyboard connected with the punch may be used for the preparation of cards while the calculator is in operation. This punch, however, does not produce any of the tapes used by the machine. The Jacquard weavers laced their cards together to provide the tapes they required for the control of their looms. The calculator, on the other hand, uses smooth tapes prepared by means of a specially designed manual punch shown in Figure 3.

Two keyboards are used interchangeably to control this punch. The first of these is used in the preparation of functional and value tapes. It has 24 columnar positions and perforates the tape in such a way as to represent any one of the ten digits in each column of a 23-figure number together with the algebraic sign. A 4-line code is used as shown in Figure 4. This figure must be read from the bottom to the top, representing the forward direction in which the tape passes through the reading mechanisms of the interpolator units.

In general, a value tape consists of a tabulation of constants punched into the tape in a given order. A functional tape, on the other hand, contains a group of entries associated with each argument. The first entry in each group is the argument itself. This is followed by the interpolational coefficients, c_n, c_{n-1}, . . ., c_1, c_0 in this order.

The main control tapes are punched by the second keyboard. It is designed to contain two lines of coding which must be punched simultaneously. This is necessary because the sequence and interpolator mechanisms, though radically different in operation, in reality are made of the same mechanical components. One numerical value in a functional tape occupies the same amount of space as two lines of control tape coding. The device

Table I

Operation	Seconds	Cycles
Addition	0.3	1
Subtraction	0.3	1
Multiplication	6.0	20
Division	11.4	38
$\text{Log}_{10} X$	72.6	242
10^x	61.2	204
Sin x	60.0	199

Howard H. Aiken, commander, United States Naval Reserve, and officer-in-charge of the computation project of the Bureau of Ordnance, is on leave of absence as professor of applied mathematics, graduate school of engineering, Harvard University, Cambridge, Mass. **Grace M. Hopper**, lieutenant, United States Naval Reserve, is associate professor of mathematics, Vassar College, Poughkeepsie, N. Y., on leave of absence for naval service.

Design and construction of the automatic sequence controlled calculator was begun in 1939 at Endicott, N. Y., and continued until August 1944, when the machine was presented formally to Harvard University by T. J. Watson, president, International Business Machines Corporation. Commander Aiken wishes to express his appreciation to Mr. Watson for the support of International Business Machines Corporation during the years of development of the calculator and further to B. M. Durfee, F. E. Hamilton, and C. D. Lake, who, together with Commander Aiken, were coinventers of the machine. The relays, counters, cam contacts, typewriters, card feeds, and card punch employed in the calculator are all standard parts of tabulating machinery as constructed by International Business Machines Corporation.

The opinions or assertions contained in this article are the private ones of the writers and are not to be construed as official or as reflecting the views of the Navy Department or the naval service at large. Material for the article has been adapted largely from "The Manual of Operation of the Automatic Sequence Controlled Calculator," *Annals* of the Computation Laboratory of Harvard University, Harvard University Press, Cambridge, Mass., volume 1, 1946. Permission to use this material has been granted.

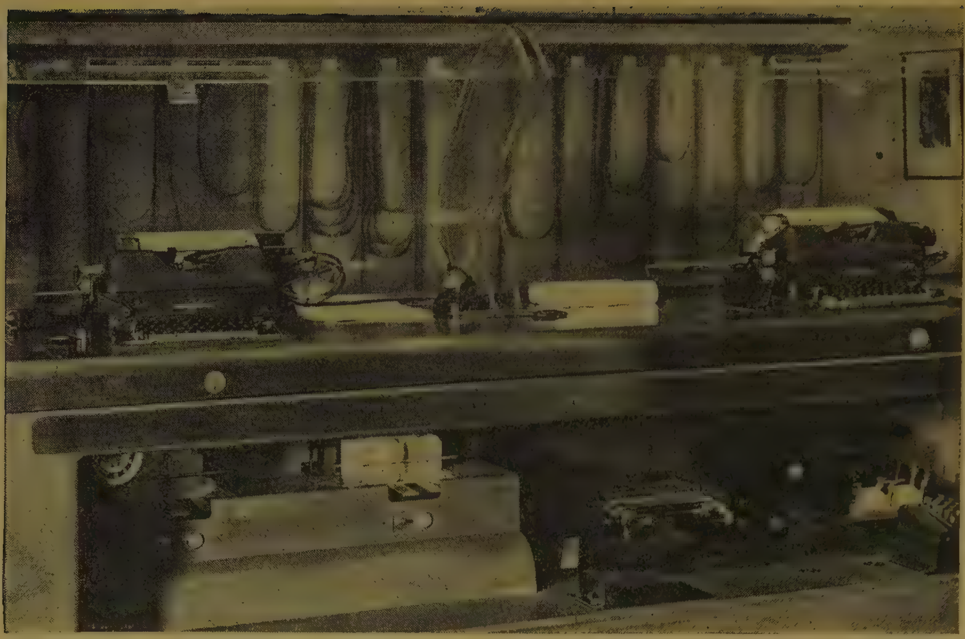


Figure 1. Typewriters, card feeds, and card punch

of setting up two lines of control tape coding per punching operation makes it possible to punch sequence control tapes and functional tapes with one and the same manual punch.

Figure 5 shows a short section of control tape. (The coding corresponds to the first ten lines of the main control tape given in the example in Table IV.) As in the case of value and functional tapes, the control tape must be read upwards. As the control tapes deal with operations only, they represent the solution of a mathematical situation independent of the values of the parameters involved. Hence, such control tapes as are of general application are preserved in the tape library for future use. Functional and value tapes of general interest likewise are preserved.

When a problem is referred to the computation laboratory, the first step in its solution is that taken by the mathematician who chooses the numerical method best adapted to computation by the calculator. Since the mathematician cannot always be present while the calculator is running, instructions must be prepared to guide the operating staff. These must include switch settings, the list of tapes to be used, plugging instructions, manual resets, information concerning checks, starting, stopping, and rerun instructions. The instructions for the plugging of the functional units usually are given in the form of diagrams. The manual resets may include the clearing of both functional and storage counters. Above the sequence mechanism are the 72 push buttons which permit manual resetting of each of the storage counters. Directly below the reset buttons and above the sequence mechanism, is a constant register which exactly duplicates one of the 60 switches. Because this register frequently is used to provide the increment of the independent variable, it is known as the independent variable switch. Further, because it is located conveniently near the sequence mechanism, this switch is particularly useful in testing the various units of the calculator.

The main sequence control is equipped to advance the tape, step by step, normally at a rate of 200 steps per minute, unless one of the subsidiary sequence controls is directed by the coding to take over command of the calculator temporarily. In this case, the control tape is stopped until the subsidiary sequence control has finished its operation and signals the main sequence control to continue operation.

The normal step rate of the sequence tape, then, does not give a good estimate of the speed of the calculator. This may be given better by citing the time required for various operations. When computing with 23 digits and operating decimal point between columns 15 and 16, division plugged for 16 comparisons, the maximum operation times are as shown in Table I. All of the times cited in Table I include the time required to transfer the arguments to the functional units and to deliver the results for further computation. The time required for all operations, except addition and subtraction, may be shortened by reducing the accuracy of the computation. Obviously, the only way to state the relative speed of the calculator is to solve a problem first by manual methods and then by use of the machine. Such an estimate has been made and apparently the machine is nearly 100 times as fast as a well-equipped manual computer. When it is borne in mind that a computer can work little more than six hours a day before fatigue causes him to produce a prohibitive number of errors, it becomes clear that, operating on a 24-hour schedule, the calculator may produce as much as six months' work in a single day.

PLANNING THE COMPUTATION

In most cases there are several methods of adapting a problem for machine computation. After all methods of attack have been considered, one usually will show distinct advantages with regard to speed and ease of operation and reliability of the checking procedures employed.

Since machine time is extremely valuable, the first

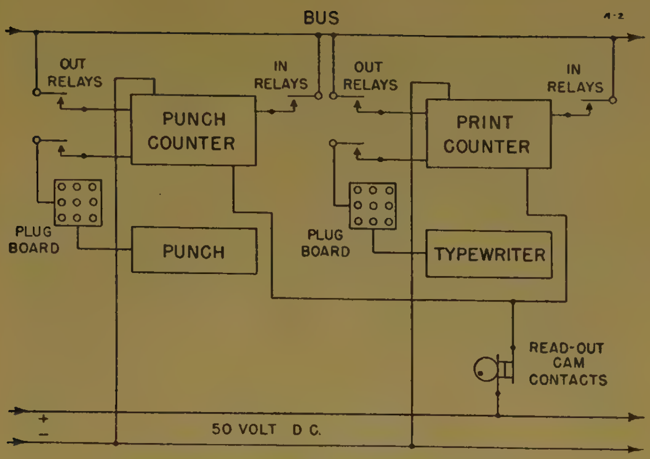


Figure 2. Print and punch counters

consideration in planning a sequence tape is to reduce the computation time to a minimum consistent with the required accuracy. However, a fine balance must be maintained between computation time and the ensuing complexity of the coding. The conservation of one or two cycles of machine time, for example, will not be profitable if it means that the counters containing essential parts of a computation must be reset before the results are checked.

The second consideration in planning a computation is ease of operation. If switches must be altered or sequence tapes interchanged at relatively short intervals of time, these operations will constitute not only a loss of time, but also a source of error.

Ease of rerunning a computation in the wake of an error and the possibility of computing for specific values of the independent variables also must be considered. Machine failures occur from time to time. The amount of time consumed in detecting the source of an error is usually dependent upon the complexity of the coding. The time required to resume operation after an error, which is dependent upon the number of manipulations the attendant must perform, should be reduced to a minimum in a well planned sequence tape.

CHECKING FOR ERRORS

Finally, of paramount importance in the design of a sequence control tape, are the checks on the computation. These must insure positive proof that the output values obtained are precisely those required and that they are correct to the desired accuracy. Four classes of errors must be taken into account:

1. Errors inherent in the mathematical formulas.
2. Errors produced by a repetition of the four fundamental operations of arithmetic.
3. Errors introduced by manual operations.
4. Errors resulting from mechanical or electrical failures within the calculator itself.

The errors inherent in the mathematical formulas must be evaluated during the preliminary analysis before the coding is begun. Decisions must be made regarding the number of terms of an infinite series to be retained, the number of times an iterative process must be applied, and the order of interpolation required. These decisions are dependent upon the interval and increment of the independent variable and the accuracy desired in the computed results.

The loss of accuracy due to the repetition of the four basic arithmetical operations in a finite digital calculator must be subjected to a detailed analysis. For each operation, the maximum error must be assumed and the error of the final result computed. The simple expedient of using a certain number of extra computing columns, in general, will nullify errors from this source. Thus, the choice of the operating decimal position will be dictated in part by the number of extra columns so allowed.

The two major sources of human error, incorrect switch settings and incorrect plugging, are perhaps the most serious of all. If the mathematical nature of a problem permits a check of the final results, independent

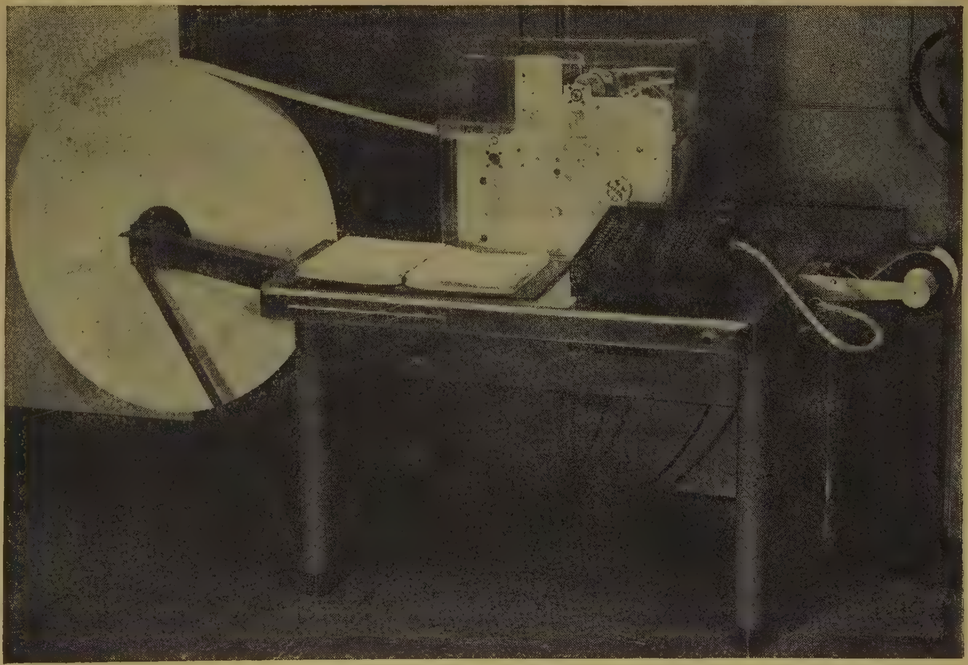


Figure 3. Manual punch

of the method of computation, the errors of the manual operations will be detected. If, however, the only checks which may be applied are those of an operational character; that is, substantiating the fact that the desired sequence of operations has been performed correctly by the calculator, such errors as incorrect switch settings may not be detected. Hence meticulous precision on the operator's part and careful checking of all manual operations are essential.

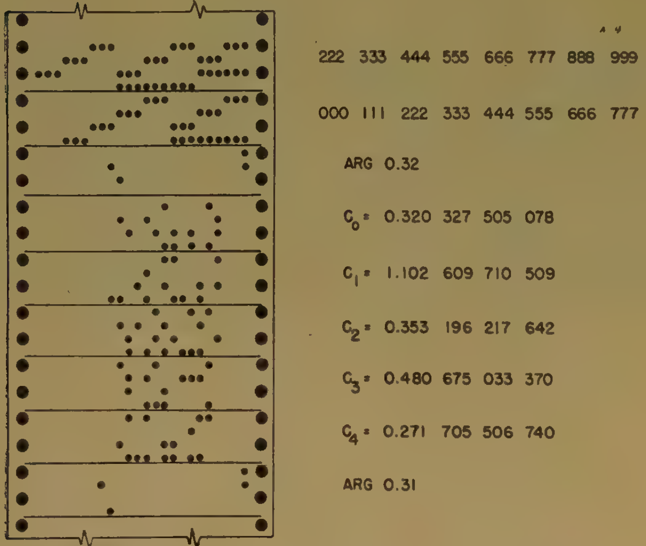

222 333 444 555 666 777 888 999
000 111 222 333 444 555 666 777
ARG 0.32
C_0 = 0.320 327 505 078
C_1 = 1.102 609 710 509
C_2 = 0.353 196 217 642
C_3 = 0.480 675 033 370
C_4 = 0.271 705 506 740
ARG 0.31

Figure 4. Value and functional tape coding

Mechanical and electrical failures within the calculator itself are the final source of errors which must be checked. If a problem is coded properly, either operational or end result checks must be provided to detect such failures. In no case must the calculator be permitted to run more than 20 minutes without checks.

It is often necessary to make preliminary computations and to set certain values in storage counters before a computation is begun. In such an event a starting tape, which usually is a short 2-ended control tape, is used.

OPERATING INSTRUCTIONS

Every sequence control tape must be accompanied by operating instructions. These instructions must be sufficiently complete to enable an experienced attendant to set up the problem and operate the calculator. Complete plugging instructions also must accompany every tape.

In the preparation of control tapes and operating instructions, a standard practice is necessary since the operation of large scale calculating machinery on a continuous basis is, of necessity, a group enterprise. The methods and techniques employed must be standardized in order that the required results may be obtained with a minimum of special instructions. The preparation of coding and of operating and plugging instructions will be illustrated by an example selected for its mathematical simplicity.

Let it be required to evaluate the polynomial,

$$F(x)=x^4+3x^3-3x^2/4-22x+3$$

in the interval $5 \leq x \leq 10$, with $\Delta x=0.01$. During every revolution of the main control tape, $F(x)$ is to be computed in two ways, by multiplication and by differences. The two independently computed values are to be compared, providing an exact check of the computation. The values of $F(x)$ are to be punched in tabulating machine cards for use in further computation. Each card must be identified by a serial number consisting of the argument, x_n, punched with its decimal point between card columns 75 and 76 and a one in the 80th card column. It is not required to print the values of $F(x)$. The tape is to be designed so that it may be rolled back and rerun without any additional manipulations. The starting tape is to be designed so that it may be used to re-establish the computation for any arbitrary value of the argument. If $F(x)$ is written in the form

$$F(x)=(((x_n+3)x_n-{}^3/_4)x_n-22)x_n+3$$

it should be clear that only three multiplications will be required to evaluate the given polynomial. In general a polynomial of nth degree will require not more than n multiplications. The constant coefficients will be supplied from switches. Since $F(x) \leq 2 \times 10^4$ in the interval under consideration, the operating decimal point may be assumed to lie between columns 15 and 16. Suppose five values of the function, F_{n-5}, F_{n-4}, F_{n-3}, F_{n-2}, F_{n-1}, to be available in punched cards. The starting tape is to be designed to feed these five cards, and compute the differences associated with the argument x_{n-1}. A switch containing Δ^4F will be used to check the fourth difference as computed by the starting tape. Therefore, before beginning the computation with the calculator, $F(x)$ for $x=4.95$, 4.96, 4.97, 4.98, 4.99, must be computed manually and punched in tabulating machine cards. Thereafter $F(x)$ will be punched in cards by the

Table II. Switch Settings

Number	Code	Setting and Purpose
1	741	$\Delta x=1$ in 14th machine column; increment of argument for computing
2	742	$\Delta x=1$ in 4th machine column; increment of argument for punch card serial numbers
4	743	1 in 1st machine column; punch card code for $F(x)$; zero check tolerance
5	7431	0.75
6	7432	22
7	74321	3
8	75	0.000 000 24
9	751	x_{n-1} = argument for computing; decimal point between columns 15 and 16; used in starting tape only
10	752	$x_{n-1}+3$; decimal point between columns 15 and 16; used in starting tape only
11	7521	x_{n-1} = argument for punch card serial numbers; decimal point between columns 5 and 6; used in starting tape only

main control tape. Hence, in the event of a machine error, any five successive values of the function, known to be correct, may be used to re-establish the computation with the aid of starting tape.

The main control tape is to be designed so that the value of the function and its differences computed in the $m-1$st revolution of the tape will be used in the mth revolution of the tape to compute the next succeeding value of the function and its differences. The switch settings, coding, operating and plugging instructions for the solution of the example are shown in Tables II, III, and IV.

OPERATING INSTRUCTIONS

1. Set switches as listed. Punch the values set in the switches and compare the punched values with the list of switch settings.

2. The quantities punched under control of the main tape are the values of $F(x_n)$. Each card is to be identified by a serial number consisting of the argument, x_n, punched in card columns 74–77 and a one, the code for $F(x)$, in card column 80. All cards punched are to be placed in the drawer provided for this purpose.

3. Five cards, labeled "starting cards," must be placed in card feed 1. These cards are identified by the serial numbers 495,001, 496,001, 497,001, 498,001, and 499,001.

4. Run starting tape. When cards run out, turn off card feed control switch and restart calculator. If the starting tape is completed correctly the sequence mechanism will stop on a blank line of tape.

5. If the check, on line 35 of the starting tape, fails, the calculator will stop on line 36, reading (1, 1, 7). The starting cards must be refed and the starting tape rerun. If the check continues to fail the counters used in the difference computation (counters 1 through 15) and switch 8 must be tested.

6. Run main control tape. If no failures occur, continue run-

Table III

Starting Tape	Line Number	A	B	C
Reset counter 1	1	1	1	7
F_{n-5} to counter 1 from card feed 1	2		1	7632
Reset counter 2	3	2	2	7
F_{n-4} to counter 2 from card feed 1	4		2	7632
Reset counter 3	5	21	21	7
F_{n-3} to counter 3 from card feed 1	6		21	7632
Reset counter 4	7	3	3	7
F_{n-2} to counter 4 from card feed 1	8		3	7632
Reset counter 8	9	4	4	7
F_{n-1} to counter 8 from card feed 1	10		4	7632
Reset counter 9	11	41	41	7
F_{n-1} from counter 8 to counter 9	12	4	41	7
$-F_{n-2}$ from counter 4 to counter 9; counter $9=\Delta F_{n-2}$	13	3	41	732
$-F_{n-3}$ from counter 3 to counter 4; counter $4=\Delta F_{n-3}$	14	21	3	732
$-F_{n-4}$ from counter 2 to counter 3; counter $3=\Delta F_{n-4}$	15	2	21	732
$-F_{n-5}$ from counter 1 to counter 2; counter $2=\Delta F_{n-5}$	16	1	2	732
Reset counter 10	17	42	42	7
ΔF_{n-2} from counter 9 to counter 10	18	41	42	7
$-\Delta F_{n-3}$ from counter 4 to counter 10; counter $10=\Delta^2F_{n-3}$	19	3	42	732
$-\Delta F_{n-4}$ from counter 3 to counter 4; counter $4=\Delta^2F_{n-4}$	20	21	3	732
$-\Delta F_{n-5}$ from counter 2 to counter 3; counter $3=\Delta^2F_{n-5}$	21	2	21	732
Reset counter 11	22	421	421	7
Δ^2F_{n-3} from counter 10 to counter 11	23	42	421	7
$-\Delta^2F_{n-4}$ from counter 4 to counter 11; counter $11=\Delta^3F_{n-4}$	24	3	421	732
$-\Delta^2F_{n-5}$ from counter 3 to counter 4; counter $4=\Delta^3F_{n-5}$	25	21	3	732
Reset counter 12	26	43	43	7
Δ^3F_{n-4} from counter 11 to counter 12	27	421	43	7
$-\Delta^3F_{n-5}$ from counter 4 to counter 12; counter $12=\Delta^4F_{n-5}$	28	3	43	732
Reset counter 5	29	31	31	7
Δ^4F from switch 8 to counter 5	30	75	31	7
$-\Delta^4F_{n-5}$ from counter 12 to counter 5	31	43	31	732
Reset check counter 72	32	74	74	7
Zero check tolerance from switch 4 to check counter 72	33	743	74	7
$\lvert\Delta^4F-\Delta^4F_{n-5}\rvert$ to check counter 72	34	31	74	71
Check; reset check counter 72	35	74	74	64
Reset counter 1	36	1	1	7
x_{n-1} from switch 9 to counter 1; argument for computing	37	751	1	7
Reset counter 2	38	2	2	7
$x_{n-1}+3$ from switch 10 to counter 2	39	752	2	7
Reset counter 64	40	7	7	7
x_{n-1} from switch 11 to counter 64; argument for punch card serial number	41	7521	7	7

Table IV

Main Control Tape	Line Number	A	B	C
Δx to counter 1; counter $1=x_{n-1}+\Delta x=x_n$	1	741	1	7
Δx to counter 64; counter $64=x_{n-1}+\Delta x=x_n$	2	742	7	7
Δx to counter 2; counter $2=x_{n-1}+\Delta x+3=x_n+3$	3	741	2	7
x_n+3 to MC re-run line	4	2	761	7
Reset counter 12	5	43	43	7
Reset counter 13	6	431	431	7
x_n to MP	7	1		7
Reset counter 14	8	432	432	7
Reset counter 15	9	4321	4321	7
Reset counter 3	10	21	21	7
-0.75 to counter 3	11	7431	21	32
$(x_n+3)x_n$ to counter 3; counter $3=(x_n+3)x_n-0.75$	12		21	7
$(x_n+3)x_n-0.75$ to MC	13	21	761	7
F_{n-1} to counter 12	14	4	43	7
ΔF_{n-2} to counter 13	15	41	431	
x_n to MP	16	1		7
Δ^2F_{n-3} to counter 14	17	42	432	7
Δ^3F_{n-4} to counter 15	18	421	4321	7
Reset counter 4	19	3	3	7
-22 to counter 4	20	7432	3	32
$((x_n+3)x_n-0.75)x_n$ to counter 4; counter $4=((x_n+3)x_n-0.75)x_n-22$	21		3	7
$((x_n+3)x_n-0.75)x_n-22$ to MC	22	3	761	7
Δ^4F_{n-4} to counter 15; counter $15=\Delta^3F_{n-3}$	23	75	4321	7
Δ^3F_{n-3} to counter 14; counter $14=\Delta^2F_{n-2}$	24	4321	432	
x_n to MP	25	1		7
Δ^2F_{n-2} to counter 13; counter $13=\Delta F_{n-1}$	26	432	431	7
ΔF_{n-1} to counter 12; counter $12=F_n$	27	431	43	7
Reset counter 5	28	31	31	7
3 to counter 5	29	74321	31	
$(((x_n+3)x_n-0.75)x_n-22)x_n$ to counter 5; counter $5=F_n$	30		31	7
F_n to punch counter	31	31	753	
Reset counter 6	32	32	32	7
F_n by multiplication to counter 6	33	31	32	7
$-F_n$ by differences to counter 6	34	43	32	732
Zero check tolerance to check counter 72	35	743	74	7
$\lvert F_n-F_n\rvert$ to check counter 72	36	32	74	71
Check; reset check counter 72	37	74	74	64
Reset counter 6	38	32	32	7
F_n from punch counter to counter 6	39	863	32	7
$-F_n$ to counter 6	40	31	32	732
Zero check tolerance to check counter 72	41	743	74	7
$\lvert F_n-F_n\rvert$ to check counter 72	42	32	74	71
Check; reset check counter 72	43	74	74	64
Reset counter 8; initiate punching	44	4	4	751
Reset counter 9	45	41	41	7
Reset counter 10	46	42	42	7
Reset counter 11	47	421	421	7
F_n to counter 8	48	43	4	
ΔF_{n-1} to counter 9	49	431	41	7
Δ^2F_{n-2} to counter 10	50	432	42	7
Δ^3F_{n-3} to counter 11	51	4321	421	7
x_n for serial number to punch counter	52	7	753	
1 in 1st machine column to punch counter	53	743	753	
Initiate punching	54			75
	55			87

ning until the card for $F(9.99)$ has been punched, then press stop key.

7. If the check on line 37 of the main tape fails, the tape must be rolled back to line 4, marked "rerun line," and the computation repeated.

8. If the check continues to fail, the computation should be re-established using the following procedure for x_n:

(*a*). Five cards from those punched under control of the main tape must be placed in card feed 1; these cards are identified by the arguments x_{n-5}, x_{n-4}, x_{n-3}, x_{n-2}, x_{n-1}, in that order, punched in card columns 74–77, and a one in card column 80.

(*b*). Switches 9, 10, and 11 must be set to the values indicated in the switch list.

(*c*). The starting procedure must be repeated and the computation continued under control of the main tape.

9. Repeated failure of the check under the roll-back procedure of instruction 7 but correct operation under the procedure of instruction 8 probably indicates that the difference computation is the source of error.

10. If it is desired to run the computation for any arbitrary value of the argument, the procedure of instruction 8 may be used.

11. The maximum time for each revolution of the control tape may be computed as follows:

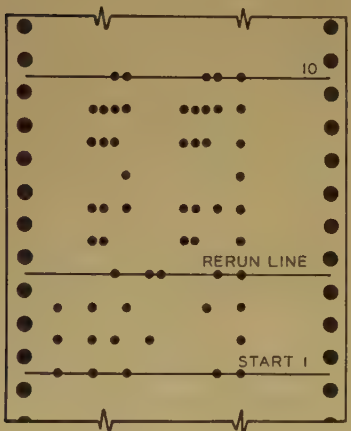
Accumulate arguments	3
Three multiplications	30
Check procedures	12
Punching $F(x)$	10
Punching serial number	3
	58 cycles = 17.4 seconds

12. The first card punched under control of the main sequence tape will be $F(5.00) = 874.25$ with the serial number 500,001.

PLUGGING INSTRUCTIONS

1. Plug the multiply unit for the standard position of the operating decimal point as shown in Figure 6.
2. Plug the card punch direct and for serial numbers as specified.
3. Plug card feed 1 direct.

Nearly two years have passed since the operation of the calculator was begun as a project of the United States Navy. During this time many problems have been solved relating to nearly every branch of physics and engineering. The problems solved include:



OUT	IN	MISC
21	21	7
4321	4321	7
4321	4321	7
1		7
431	431	7
43	43	7
2	761	7
741	2	7
742	7	7
741	1	7
A	B	C

Figure 5. Control tape coding

1. The tabulation of functions of a real variable.
2. The subtabulation of functions.
3. The tabulation of functions defined by formulas involving empirical variables.
4. The tabulation of functions of a complex variable.[1]
5. The solution of systems of linear algebraic equations.
6. Statistical analyses.
7. The determination of zeros of functions.
8. The evaluation of definite integrals.
9. The solution of systems of ordinary differential equations.
10. The solution of partial differential equations.

From time to time, the solution of these problems has required permanent changes in the wiring of the calculator, and the inclusion of new features, many of which have improved its operation greatly. Such improvements and alterations are still in process of development. As a result, this article represents the standard procedure of the Computation Laboratory as of the fall of 1945.

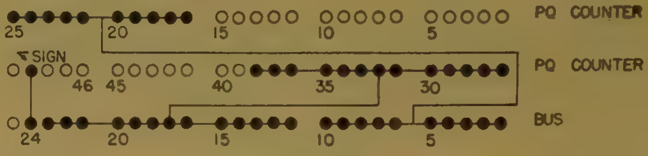


Figure 6. Multiplication plugging diagram

This discussion of the calculator and of the techniques used in its operation is all too brief. However, a description of the calculator including details of its circuits, the coding and plugging procedures, and methods of solution of problems are included in its manual of operation.[2]

The design and construction of the calculator was begun in 1939 and, almost immediately upon its completion in 1944, it was placed in operation by the Bureau of Ships of the United States Navy where work was continued until January 1946, when the project was transferred to the Bureau of Ordnance. With regard to the operation of the machine throughout the past two years, many of the operating techniques described in this article, written at the request of Professor Chester L. Dawes of Harvard University, resulted from the work of the staff of the computation project. In particular, Lieutenants (junior grade) R. V. D. Campbell and R. M. Bloch have made important contributions in the field.

REFERENCES

1. Tables of the Modified Hankel Functions of Order One-Third and of Their Derivatives, *Annals* of the Computation Laboratory of Harvard University, Harvard University Press, Cambridge, Mass., volume 2, 1945.

2. The Manual of Operation of the Automatic Sequence Controlled Calculator, *Annals* of the Computation Laboratory of Harvard University, Harvard University Press, Cambridge, Mass., volume 1, 1946.

INSTITUTE ACTIVITIES

Seattle Section Is Host to First Postwar Pacific Coast Meeting

The Pacific Coast meeting was held in Seattle, Wash., August 27–30, 1946, with headquarters in the Olympic Hotel. A well-balanced program was offered, comprised of nine sessions, including a student session and a session devoted to a discussion on the organization of the engineering profession, interspersed with inspection trips, a golf tournament, and social events for both men and women. Judged by the many enthusiastic comments received, the meeting was highly successful. The total attendance of 562 was a record for Pacific Coast meetings and more than double the attendance at the last meeting held in Seattle in 1935.

Technical sessions were on atomic power, central stations, industrial and railroad problems, aviation, power systems, and communication. Many of the papers presented dealt with problems of particular interest to West Coast members, where transmission lines are long and large blocks of hydroelectric power are concentrated.

OPENING SESSION

The meeting was opened by J. Hellenthal (M '23) general chairman, who introduced William F. Devin, mayor of Seattle. A cordial welcome was extended by the mayor, who referred briefly to the history of the city and expressed hope for a successful meeting. Responses to the welcome were made by Vice-President Charles F. Terrell (M '18) and President J. Elmer Housley (F '43). In conclusion, Vice-President Terrell stated that the foregathering was to review the changes brought about by the war and to take stock of what lies ahead.

RESPONSE BY PRESIDENT HOUSLEY

President Housely paid tribute to the speakers, Past Vice-President C. B. Carpenter (F '44), and the spirit of hospitality shown in the Pacific Northwest. He referred to the industrial development, natural resources in the area, and the well-known valuable contributions which its industries made to the war effort and victory.

Speaking on the industry with which he is most familiar, President Housley explained that just before and during the war the Aluminum Company of America embarked on an expansion program entirely self-financed and in addition undertook, without fee or profit, the building and operation of some $500,000,000 worth of aluminum plants for the government. He stated that the large smelting plant in Vancouver with an original capacity of 30,000,000 pounds a year since has been increased fivefold. He assured the meeting that the aluminum industry in the Pacific Northwest was there to stay, and he was glad to know that competitors would keep in operation smelting plants at Troutdale, Oreg., and Spokane, Wash., as well as the sheet rolling mill at Spokane. In the building of these plants for the government Alcoa put into them all of the "know-how" of nearly 60 years of the aluminum business.

As further concrete evidence that the industry was in the region to stay President Housley cited the continuance of experiments on processes for the use of low-grade laterite ore found in Oregon and active plans to bring high-grade limestone from Alaska into the Pacific Northwest area for use in the manufacture of alumina and for other important purposes.

In conclusion, President Housley spoke of the other engineering developments in the Northwest, including the early and recent hydroelectric developments, transportation, mining, steel mills, saw mills, and the aviation industry. He urged members to take back with them the enthusiasm engendered by the meeting, the story of engineering progress told at the technical sessions, and most of all the encouragement of professional development.

ATOMIC POWER

One of the highlights of the meeting was an address on "Development of Atomic Power" by Bruce R. Prentice of the General Electric Company. This was particularly fitting on the eve of the taking over of the Hanford plant for the production of plutonium by the General Electric Company under a broad program of research and development of atomic energy for power.

Recognizing the general interest in knowing when atomic power for commercial use will become a reality, Mr. Prentice pointed out that predictions mean little if the stage of development is not also clearly defined. Though he admitted that charting the course of development at this time is impossible, he noted that intensive development is under way at the General Electric Company and Clinton Laboratories, Oak Ridge, Tenn. The Clinton project may produce moderate amounts of power in two years. With this date as the first milestone, Mr. Prentice predicted rapid expansion, improvement, and changes, and that in perhaps 25 years atomic power should be in widespread use on many different applications.

By slide the schematic structure of the uranium pile was shown, and the control of the chainlike reaction by means of positioning boron or cadmium control rods through the pile was explained. Boron or cadmium readily capture the slow neutrons. Other important factors were discussed, such as what determines the size of the pile, poisoning effects within the pile, radiation stability within the pile, shielding to stop the neutron and gamma rays, and safety to prevent explosion.

With respect to the engineering problems six possible nuclear power systems were considered. Two of these systems, using liquid convection or evaporation of liquid to vapor, employ heat exchangers which also would have to be shielded. One of the systems, to obtain electricity directly from the pile, would depend upon radical new invention. Controls probably would have to be automatic, much faster, and integrated with considerable instrumentation to measure various quantities. The matter of heat transfer also presents engineers with challenging problems, such as getting the heat out of the pile just as fast as possible. A considerable amount of development work would be needed to find fluids, including liquid metal alloys and gases, which will not change their properties in operation. Materials must withstand high temperatures, and appreciable erosion could not be permitted as replacement of parts within a pile would be extremely difficult. Transmutations of the fluid, pipes, and so forth, may complicate greatly a solution to the materials problem.

On the economics side Mr. Prentice likened the cost of fuel to an investment which would last for a considerable period of time, and he mentioned the need to reclaim the critical materials from the ash.

He mentioned three limitations to all applications. First the shields probably will continue to be both large and heavy. Second, the cost of fuel, magnitude of initial investment, combined with a considerable

Analysis of Attendance at 1946 Pacific Coast Meeting

Classification	Seattle	District 9*	District 8	District 10	Miscellaneous	Totals
Members	159	88	55	9	20	331
Men guests	55	13	8		8	84
Women guests	43	40	32	4	10	129
Students	15	3	10			28
Totals	272	144	105	13	38	572

* Outside of Seattle Section territory.

cost of refueling as well as the handling and reclaiming of critical materials, may limit application greatly. Third, the health hazards, although they can be safeguarded, will require constant vigilance and much instrumentation, which will influence the design of atomic power plants. Applications were forecast in the following order. The first application probably would be naval and merchant marine ships, where long life of fuel and the small volume would probe attractive. The second application might be for mining and other activities in remote places, where it is difficult to obtain power supply. The third use may be for emergency power plants. Fourth would be use by the public utilities, depending on economic and national policy factors. Fifth would be the application to railroads, aircraft, and other means of transportation, which was put last due to shielding limitations and to a lesser extent the investment, maintenance, and safety limitations previously discussed.

In conclusion, Mr. Prentice explained that the address would not be submitted for publication, because he had largely drawn his material from articles by H. A. Winne, Doctor C. G. Suits, and Doctor Kenneth H. Kingdon, published in the Edison Electric Institute *Bulletin* for June 1946.

In the remainder of the session two papers were presented, which described "Columbia River Power" and "Power System Development for Service to the Hanford Plutonium Plant."

STUDENT CONFERENCE LUNCHEON

The student conference luncheon, held Wednesday, August 28, was well attended by Institute officers, counselors, and representatives of the various Branches. Among the officers present were President Housley, Vice-President F. F. Evenson (M '29), Secretary H. H. Henline (F '43), and Director W. C. Smith (F '40). Secretary Henline spoke briefly, expressing pleasure at seeing the group gathered together on the 20th anniversary of the first Student Branch conference, which was held at Salt Lake City, and also marking his 20th year at Institute headquarters. He referred to the difficulties of operation of the Student Branches during the depression and the war years and hope was expressed that with a fresh start the Student Branch activities would meet with great success.

President Housley expressed pleasure at being with the group, saying that he always was interested in the students and members of the faculties in educational circles. He said it was important that the students and counselors work together in the Institute and with industry. The question was raised as to why the colleges do not prepare more students for the management of industry. Engineers should be just as well prepared to take over the management of a bank as a lawyer. He also expressed belief that a little too much glamor and fascination had been attached to the subjects of electronics and atomic energy, as in the final analysis a high percentage of the engineering employment would be found in the 60-cycle field. In conclusion President Housley expressed hopes that our neighbors across the seas would work with use for better living standards and organization within those countries.

Different views were held by several of the Student Branch counselors in regard to the joint operation of Student Branches. On the one hand Professor A. L. Albert (F '41) and others believed that AIEE would lose its identity through the broadening of activities and the holding of joint Student Branch meetings. Financially, it was cited, the Branches are a liability to the Institute, in that the $3 dues do not cover the cost of operation and the publications. On the other hand Professors F. E. Terman (F '45), P. L. Morton (M '43), and others were in favor of combined operation, as it tended to reduce the competition and distinction between the fields of communication and electrical engineering. Student Branch chairmen or representatives from several of the Branches briefly reported on the Student Branch activities of the Branches in Districts 8 and 9. Dean E. W. Schilling (F '44) chairman of the committee on Student Branch activities, District 9, presided.

BANQUET

The banquet was held Thursday, August 29, and provided an enjoyable evening to many members and guests. Music was supplied by the Olympic String Orchestra and Mr. Moody entertained with sleight-of-hand tricks and Arthur Anderson with impersonations. Vice-President Terrell was toastmaster.

After the dinner Secretary Henline presented the prize for best paper in the North West District to E. C. Goodale (M '45) and J. I. Holbeck (M '36) for their paper entitled "Field Determination of Current Transformer Errors by the Secondary-Voltage Method," which was presented at a meeting of the Portland Section, April 3, 1945. He also presented the prize for best paper in the Pacific District to J. V. Kresser (M '43) for his contribution entitled "Characteristics and Limitations of Transformer Connections," which was presented at a meeting of the San Francisco Section, November 16, 1945.

The banquet was addressed by President Housley, who complimented the committee on the success of the meeting, the scope of the technical program, and the value of the social events. Reference also was made to the abundance of opportunity held by the Northwest for the younger generation, in view of the richness of its natural resources. The history and rapid growth of the Institute was surveyed briefly and President Housley expressed hope that the gain in one direction would not become a loss in another. In taking stock of the situation he explored the relation between science and industry and referred to the seven major developments that took place during the war in the realm of physics, electronics, chemistry, metallurgy, aerodynamics, electric machinery, and power systems. In conclusion, he stated that the AIEE is the universal society for the consideration of these new developments in their relation to electrical engineering.

Prizes for the golf tournament, held on the course of the Inglewood Golf and Country Club on the previous day were presented by C. R. Kingsbury (M '39) chairman of the golf committee. The winner of the Fisken cup was George Palo (M '41) of Seattle, who was presented with a leather golf bag. Second low net was J. W. Ferguson (A '40), who received a golf jacket, and third low net was W. S. Hill (M '20), who received a sport shirt.

First low gross score was made by J. C. Henkle (M '36) of Portland; second low gross, W. J. Mosley (A '43) of Seattle; and third low gross K. J. McLean (A '43) of Seattle. These winners respectively were presented with golf shoes, a chipper, and a lightweight canvas golf bag. Other prizes were presented for the nonmember contest, as well as kicker's handicap, long drives, closest to the pin, and for birdies.

ORGANIZATION OF THE ENGINEERING PROFESSION

The session providing opportunity for discussion on the organization of the engineering profession was highly successful. The subject was introduced by Vice-President Carpenter who presided and who explained that the board of directors had authorized that a study should be made by the committee on planning and co-ordination, of which Vice-President J. F. Fairman (F '35) is chairman. The committee has appointed two subcommittees to carry out the work,—the professional activities subcommittee, T. G. LeClair (F '40) chairman, and the technical activities subcommittee, M. D. Hooven (F '44) chairman. Discussers were requested to use their Section affiliation.

The progress made so far was reviewed by Vice-President Fairman, who explained that the procedure was by method of trial and observation. With the aid of slides the four plans of organization developed by the professional activities subcommittee were reviewed and the questionnaire form, although not perfect, was considered a satisfactory vehicle for evaluation.

The meeting was open for discussion, and much enthusiasm was shown by members and Section representatives on the West Coast, who presented specific problems in their localities and stated reasons for the preference of one or more of the several plans. In general, most speakers expressed satisfaction with the technical activities, but the discussion presented many varied problems on the professional activities side. The results obtained from the questionnaire will prove most valuable to the committee on planning and co-ordination in carrying on the work.

TECHNICAL SESSIONS

The technical sessions were of broad scope and well attended, and keen interest was manifested in both the presentations of the papers and discussion which followed. Besides the session on atomic power, other high spots of the program consisted of an address in the aviation session "Air Industrial Preparedness Planning" by Lieutenant Colonel Bert R. Kuss, United States Army Air Corps. A feature of the communication session consisted of a review of present status of television, which was presented by R. D. Kell of RCA Laboratories. Mr. Kell demonstrated the remarkable pickup of the new camera tube, called an Image Orthicon, which is more than 100 times as sensitive as the iconoscope, and under some conditions more than 1,000 times as sensitive.

ENTERTAINMENT

Besides the banquet, a reception to the president was held on the first evening of the meeting, and on the second evening as many members as could be accommodated attended a play, "Pomeroy's Past," at the Pent House Theatre at the University of Washington. During the meeting a number of the women were entertained on an automobile tour of the city and the environs, a bridge luncheon at the Seattle Tennis Club, and a boat cruise on Lake Washington.

INSPECTION TRIPS

Many members who attended the meeting took advantage of the various inspection trips and visited the Puget Sound Naval Ship Yard, Seattle Naval Station, Boeing Aircraft Company, and other industrial plants, as well as the several power plants.

Aid for AIEE Committees Provided at Headquarters

As a means of fulfilling the proposal made by the AIEE board of directors at its May meeting that the headquarters staff be strengthened to increase the effectiveness of the management and administration of the Institute, an assistant to the secretary of the Institute has been added to the headquarters staff.

Charles C. Wilson (M '43) new assistant to the secretary, has the duty of assisting the technical committees. Chairman of the technical committees have been invited to communicate with Mr. Wilson regarding the types of assistance which he might extend their committees. Details of Mr. Wilson's previous career may be found on page 534 of this issue.

AIEE Subcommittee Surveys Vacuum Tube Types

In the interest of providing more reliable vacuum tubes for use in electronic instruments, the AIEE subcommittee on electronic instruments is conducting a survey among more than 400 instrument manufacturers to determine what types of special tubes should be made and what the demand would be for each of these special types. The subcommittee on electronic instruments is a joint subcommittee of the committee on electronics and the committee on instruments and measurements.

Information obtained from the survey will be tabulated, published as a committee report, and made available to all vacuum tube manufacturers, most of whom already have expressed their interest. The subcommittee then plans to formulate standards for tubes with more uniform tube characteristics, more rugged construction, better stability, longer life, lower hum, and reduced microphonic effects.

Future AIEE Meetings

Winter Meeting
New York, N. Y., January 27–31, 1947

North Eastern District Meeting
Worcester, Mass., April 23–25, 1947

Summer Meeting
Montreal, Quebec, Canada, June 9–13, 1947

It is the desire of the subcommittee that readers of *Electrical Engineering* assist in the survey by making certain that their companies receive questionnaires.

Committee for First Midwest Meeting Appointed

The committee has been appointed to make arrangements for the first AIEE Midwest meeting, which will be the fourth yearly meeting of the Institute. The first of the Midwest meetings will be held November 3–7, 1947, in Chicago, Ill. Inauguration of the Midwest meeting was approved by the executive committee of the board of directors in April 1946 upon recommendation of the committee on planning and co-ordination.

Members of the committee are:

F. H. Lane (F '37) *chairman;* Dwight L. Smith (M '27) *vice-chairman;* F. V. Smith (M '38) *secretary;* N. C. Pearcy (F '43) *treasurer;* D. L. Bement (M '44); O. W. Eshbach (F '37); J. E. Hobson (M '41); L. R. Janes (M '29); P. B. Juhnke (F '36); T. G. LeClair (F '40); J. R. North (F '41); R. R. O'Connor (M '43); R. I. Parker (M '20); and H. K. Smith (F '44).

SECTION• • • • • •

Illinois Valley Section Schedules Year's Meetings

The full year's schedule of meetings for 1946–47 recently was issued and distributed by the Illinois Valley Section, reflecting the interest, activity, and foresight of the officers of this new Section. Gordon H. Duff (A '45) application engineer for the Westinghouse Electric Corporation, Peoria, Ill., is the chairman of the Section's program committee. The Section was established formally June 30, 1946, with an initial membership of 47 compared with which its August 1, 1946, membership of 80 represents a 70 per cent growth.

The first of the current season's meetings was held in Peoria, Ill., September 5, and was addressed by Doctor D. E. Noble, director of research for the Galvin Manufacturing Corporation, Chicago, on the subject, "Two-Way Radio Communication With Mobile Units." The second meeting was scheduled for October 3, at Pekin, Ill., and addressed by D. R. Siewert, district superintendent of service shops for the General Electric Company, Chicago, on the subject, "Electrical Maintenance." The third meeting scheduled for October 17 at Springfield, Ill., was addressed by G. O. Paden of the engineering and service division, Westinghouse Electric Corporation, Pittsburgh, Pa., on the subject, "The Impact of Radar in War and Peace." Nine additional meetings of a similar type are listed covering programs for the remainder of the operating year.

T. A. Hopkins (A '44) electrical research engineer for the Caterpillar Tractor Company, Peoria, is the new Section chairman, and C. T. Borchelt (A '45) construction engineer for R. G. LeTourneau, Inc., is Section secretary. E. W. Stone (M '37) distribution engineer for the Central Illinois Light Company, Peoria, is chairman of the Section's printing and mailing committee which is responsible for keeping Section members informed concerning committee personnel, Section projects, and Section activities in general.

Nuclear Physics Introduces 1946–47 Season for St. Louis

The beneficial aspects of nuclear physics were discussed by Doctor A. L. Hughes of Washington University and J. T. Wilson of the Allis-Chalmers Manufacturing Company at the first meeting of the AIEE St. Louis Section for the 1946–47 season.

Doctor Hughes explained the various methods by which high energies can be imparted to particles for probing the atoms and the theory behind the Van der Graf electrostatic generator, the cyclotron, the betatron, and the linear accelerator. The advantages and limitations of each were delineated from both the economic and the scientific viewpoints.

Greater detail on the betatron was given by Mr. Wilson, who after describing its mechanism, briefly considered the possibilities of using the X rays produced by the betatron in industrial radiography and in cancer therapy.

The technical program of the St. Louis Section for the current season includes monthly meetings by its technical discussion groups on electronics, illumination, and industrial power practices. The illumination group is newly organized.

Officers of the Section for 1946–47 are:

Chairman: O. T. Farry (M '40).

Vice-Chairman: E. S. Rehagen (M '42).

Secretary-Treasurer: R. W. Gaskins (M '37).

Chairman, meetings and papers committee: O. V. Tally (M '44).

Chairman, membership committee: S. F. Joyce, Jr. (A '44).

Chairman, entertainment committee: R. W. Schoetker (M '45).

Chairman, fellowship committee: H. M. Du Phorne (A '29).

Chairman, educational committee: L. O. Campbell (M '29).

Chairman, student activity committee: D. A. Fischer (A '42).

Chairman, publicity committee: J. C. Lebens, Jr. (A '41).

27th Subsection Formed at Canton, Ohio

AIEE members in the environs of Canton, Ohio, held an organization meeting on September 4, 1946, for the 27th Subsection of the Institute, which is in the territory of the Akron Section.

The new Subsection, which has 33 members, will hold monthly meetings in Canton. Officers elected at the first meeting are:

Chairman: R. C. Wey (A '32) of the Ohio Power Company.

Secretary-Treasurer: H. E. Rue (A '39) of the Hoover Company.

Program Chairman: L. S. Steiner (A '40) of the Timkin Roller Bearing Company.

Membership Committee Chairman: George Elliott of the Hoover Company.

The Canton Subsection organization committee was composed of H. T. Welser (A '38), K. F. Sibila (A '38), and G. S. Ketter.

At a recent meeting of the governing board, the Akron Section voted to extend all possible help to the Canton group in its new venture. The members in the Canton area are reported to be enthusiastic about the enlarged facility for the expanded range of activities afforded by the formal organization of the Subsection.

PERSONAL ● ● ● ●

John Fyfer Calvert (A '27, M '35, F '45) professor and chairman of the department of electrical engineering, Northwestern Technological Institute, Evanston, Ill., has been appointed chairman of the AIEE committee on Student Branches for 1946–47. Professor Calvert, who was born October 14, 1898, in Columbia, Mo., received from the University of Missouri the degrees of bachelor of science in 1922 and electrical engineer in 1924. He also holds the degrees of master of science (1930) and doctor of philosophy (1936) from the University of Pittsburgh. He entered the graduate student course at the Westinghouse Electric Corporation, East Pittsburgh, Pa., in 1923, and from 1924 to 1936 he was electrical engineer in the power engineering department of the company. In 1936 Professor Calvert commenced his teaching career as associate professor of electrical engineering at Iowa State College, Ames. He joined the faculty of Northwestern University in 1938 and became chairman of the department of electrical engineering at the technological institute in 1939. In 1941 and 1942 Professor Calvert was associated with the Naval Ordnance Laboratory, Washington, D. C., on various projects including construction work in Chesapeake Bay, and electrical installations at Pearl Harbor, T. H. From 1942 to 1944 he was in charge of projects at Northwestern University under contract with the Office of Scientific Research and Development. During the war he also organized the United States Naval Training School at Northwestern University and an Ultrahigh Frequency School for the United States Army Signal Corps. Professor Calvert served in the United States Infantry during World War I on the Mexican border and in France. He is the author of many technical articles and holds a number of patents concerned with lightning protection of insulation and with high-voltage a-c generators. He has been active in the work of the AIEE Chicago Section and has been a member of the AIEE committee on electric machinery since 1939. He also is a member of the American Society for Engineering Education, the Western Society of Engineers, Tau Beta Pi, Eta Kappa Nu, Sigma Xi, and the American Association for the Advancement of Science.

J. F. Calvert

R. K. Honaman

W. R. Smith

W. R. Smith (M '18, F '30) safety engineer, Public Service Electric and Gas Company, Newark, N. J., has been appointed 1946–47 chairman of the AIEE headquarters committee. He was born in Charleston, S. C., February 23, 1885, and was graduated from Clemson Agricultural and Mechanical College in 1906 with the degree of bachelor of science in electrical engineering, receiving the degree of electrical engineer in 1928. During 1907 he was employed as secretary and assistant to the head of the engineering department at Clemson College and in 1908 entered the employ of the Hartford Suspension Company, Jersey City, N. J., as draftsman. He became manager of the company's New England office, Boston, Mass., in 1909, of its Newark office in 1911, and was placed in charge of the department of design in Jersey City in 1912. During 1913 he was salesman for the White Motor Car Company, Newark. His association with the Public Service company commenced in 1914 in the electrical construction department, and from 1917 to 1922 he was field engineer in charge of construction work. With the formation of the Public Service Production Company, Newark, in 1922, he became superintendent of electrical construction and in 1924 was appointed managing electrical engineer. In 1927 he was made assistant chief engineer and as such also was employed by the Newark branch of the United Engineers and Constructors, Inc., from 1928 to 1935. In 1936 he returned, as transmission construction engineer, to the Public Service Electric and Gas Company. Since 1938 he has been safety engineer. He has been active on the following committees: publications, co-ordination of Institute activities, Alfred Noble Prize, safety, board of examiners, award of Institute prizes, and finance. In addition he has served as chairman and as secretary of the New York Section. He has served on the National Fire Waste Council and on committees of the National Fire Protection Association and holds membership in the National Society of Professional Engineers, the Edison Electric Institute, the American Society of Safety Engineers, and the National Safety Council.

Richard Karl Honaman (A '16, M '36, F '36) director of publication, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed chairman of the newly formed AIEE committee on publicity for 1946–47. Mr. Honaman was born September 17, 1895, in Lancaster, Pa., and holds the degrees of bachelor of science (1916) and master of science (1917) from Franklin and Marshall College. After a year as instructor at Franklin and Marshall College, Lancaster, he became assistant physicist with the National Bureau of Standards, Washington, D. C., in 1917, and in 1918 was named associate physicist. In 1918 and 1919 he was also assistant professor at George Washington University, Washington. In 1919 Mr. Honaman joined the American Telephone and Telegraph Company, New York, as engineer in the department of development

J. D. Tebo

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J. W. Barker

D. A. Quarles

R. L. Jones

and research, and in 1926 he was named to the inductive interference staff. He was titled assistant protection development engineer in 1930. While in this position he was chairman for the Bell Telephone System of Joint Project Committees with the Edison Electric Institute. Mr. Honaman was assigned to the staff of Bell Telephone Laboratories as protection methods engineer in 1934. During the recent war he was director of the Laboratories' school of war training, which trained more than 4,000 men and prepared instruction manuals. Mr. Honaman later was appointed assistant director of publication and in 1945 was made director. He holds a number of United States patents and is a member of the AIEE publication committee.

Reginald Lamont Jones (A '11, M '17, F '31) director of apparatus development, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed 1946–47 chairman of the AIEE committee on constitution and bylaws of which he has been a member since 1942. Doctor Jones was born in New York, N. Y., February 28, 1886. He received a bachelor of science degree in electrical engineering in 1909, a master of science degree in 1910, and a doctor of science degree in 1911, all from the Massachusetts Institute of Technology. Following a year as instructor in electrical engineering at Lowell Institute for Industrial Foremen, Boston, Mass., he became a member of the research staff of the Western Electric Company, New York, N. Y., and in 1914 was placed in charge of the transmission research department. Doctor Jones took charge of the inspection engineering department in 1923, and, when the Western Electric Company's research department became the Bell Telephone Laboratories, in 1925, he retained that position with the new company for which he organized and directed a new department to establish a scientific basis for inspection operations in factory and field. In 1927 he assumed charge of the outside plant development department, and in 1928 he was made director of apparatus development. In 1941 Doctor Jones was appointed a representative of AIEE on the Engineers' Defense Board. His society affiliations include the American Physical Society, the Acoustical Society of America, the American Association for the Advancement of Science, and the Academy of Political Science.

Donald Aubry Quarles (A '23, M '29, F '41) director of apparatus development, Bell Telephone Laboratories, Inc., has been appointed chairman for 1946–47 of the AIEE finance committee of which he has been a member since 1944. Mr. Quarles, who was born July 30, 1894, in Van Buren, Ark., received the degree of bachelor of arts from Yale University in 1916. He served as a captain of field artillery in the first World War and in 1919 entered what was then the engineering department of the Western Electric Company, New York, N. Y., which in 1925 became Bell Telephone Laboratories, Inc. He was concerned with transmission engineering research until in 1924 he was given charge of apparatus inspection engineering. He was transferred to the outside plant development department in 1928 and served successively as plant system engineer, assistant director of apparatus development (1935), and outside plant development director (1940). Later in 1940 he was titled director of transmission development and in 1944 director of apparatus development. Mr. Quarles has served on the AIEE committees on the Edison Medal, electronics, instruments and measurements, and is currently serving as an AIEE director and on the Library Board of the United Engineering Trustees. He also is serving on the board of trustees of the AIEE Retirement System. He is a member of the American Physical Society.

Julian Drenner Tebo (A '36, M '36) supervisor, machine switching laboratory, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed 1946–47 chairman of the AIEE committee on basic sciences of which he has been a member since 1937. Born July 5, 1903, in Harpers Ferry, W. Va., Doctor Tebo received the degrees of bachelor of engineering in 1924 and doctor of engineering in 1928 from Johns Hopkins University. In 1924 and 1925 he took the student training course in meter and relay operating at the Westinghouse Electric Corporation, East Pittsburgh, Pa. His association with Bell Telephone Laboratories commenced in 1928, at which time he engaged in electromagnetic design, particularly as applied to the reduction of interference between power and telephone lines. Following this he was assigned to cross bar machine switching, designing electromagnets and establishing requirements. During World War II he worked on the development and manufacture of radar and sonar devices. Active in the affairs of the New York Section, Doctor Tebo was chairman of its basic science group for 1945–46 and is chairman of the program committee for 1946–47. He has taught courses in electromagnetic design and manufacturing methods for Bell Laboratories and is a member of Sigma Xi.

Joseph Warren Barker (M '26, F '30) president, Research Corporation, New York, N. Y., has been appointed chairman of the AIEE committee on research for 1946–47. Doctor Barker was born in Lawrence, Mass., June 17, 1891, and holds several degrees from Massachusetts Institute of Technology. From 1930 to 1946 he was dean of the faculty of engineering at Columbia University, New York. Exceptionally prominent in the committee work of the AIEE, Doctor Barker has served on the following committees: production and application of light, education, Edison Medal, planning and co-ordination, Fortescue Fellowship, award of Institute prizes, and publication. He also represents the AIEE on the council of the American Association for the Advancement of Science, and the United States National Committee of the International Commission on Illumination. For a more detailed biography of Doctor Barker see the May issue of *Electrical Engineering*, page 228.

Tomlinson Fort (A '27, M '35) manager, central station department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed 1946–47 chairman of the AIEE committee on membership of which he has been a member since 1943. Mr. Fort was born December 9, 1902, in Atlanta, Ga., and was graduated from the New Mexico College of Agriculture and Mechanic Arts with the degree of bachelor of science in 1923. After completing the graduate student course at the Westinghouse company in 1924, he was named application engineer in the power department. He was transferred to Albany, N. Y., as engineer and salesman in 1927 and in 1930 was given charge of the Albany office. The following year he became central station representative for the company in New York, N. Y., and returned to East Pittsburgh in 1940 as assistant manager of the central station department. He was appointed manager of the department in 1944. Mr. Fort has been active in AIEE Section activities and is a registered professional engineer in New York State.

George S. Whitlow (A '29, M '39) electrical engineer, Union Electric Company of Missouri, St. Louis, has been appointed chairman for 1946–47 of the AIEE committee on automatic stations of which he has been a member since 1941. Born in Hamburg, Ark., August 8, 1902, Mr. Whitlow was graduated from the University of Arkansas with the degree of bachelor of electrical engineering in 1924. He entered the General Electric Company test course in Schenectady, N. Y., in 1924 and was made head of automatic switchgear testing at the Schenectady and Philadelphia, Pa., plants in 1926. He was transferred to Fort Wayne, Ind., where he continued to work on automatic switchgear and while in this position supervised installations in Havana, Cuba. He was sent to St. Louis as application engineer for the company in 1928. In 1941 Mr. Whitlow joined the Union Electric company. He is the author of several technical papers.

Donald Elliott Moat (A '29, M '39) district manager, technical division, Leeds and Northrup Company, Cleveland, Ohio, has been appointed 1946–47 chairman of the AIEE committee on transfers of which he has been a member since 1945. Mr. Moat was born January 22, 1902, in Slingerlands, N. Y., and received the degree of mechanical engineer from Rensselaer Polytechnic Institute in 1924. After a period in the apprentice course and planning division of the Westinghouse Electric Corporation, Philadelphia, Pa., Mr. Moat entered the training course of Leeds and Northrup Company, Philadelphia, in 1925. At first assigned to service and sales work in Philadelphia, he later was transferred to Cleveland as district manager of the technical division. He is registered as a professional engineer in Ohio.

C. C. Wilson (M '43) has joined the AIEE headquarters staff in New York, N. Y., as assistant to the secretary to assist the technical committees. Mr. Wilson was born July 31, 1912, in Pueblo, Colo. He received the bachelor of science degree in engineering from Trinity College in 1933 and the bachelor of science degree in electrical engineering from Massachusetts Institute of Technology in 1935. He became an assistant in the electrical laboratory of the Ward Leonard Electric Company, Mount Vernon, N. Y., in 1935, and was named electrical design engineer in 1937. In 1942 he was placed in charge of the design section of the engineering department and in this position supervised development on electric motor control apparatus for the United States Navy. He is a member of Sigma Xi.

K. A. Auty (A '12, M '17) sales engineer, Commonwealth Edison Company, Chicago, Ill., has retired. Mr. Auty was born in England in 1878. After earning a second mate's certificate in the Royal Navy, he attended the Sorbonne and in 1899 was graduated from Victoria University. From 1899 to 1907 he was with the Brush Electrical Engineering Company, Ltd., Loughborough, England, first as draftsman and member of the technical staff; later as branch manager and engineer for the company's Lancashire, Cheshire, and Cumberland districts; and finally as company representative and erecting engineer in Japan. He joined the British Columbia Electric Railway Company, Ltd., Vancouver, Canada, as chief illuminating and power engineer in 1909. As sales engineer and isolated plant specialist he entered the employ of the Commonwealth Edison Company in 1915. In 1917 he received the Insull medal. Mr. Auty was AIEE vice-president for 1932–34, was one of the organizers of the AIEE Vancouver Section, and is a former officer of the Chicago Section. He assisted in the founding of the Midwest Power Engineering Conference and served as one of its officers for a number of years. An active member of the Western Society of Engineers, he has served on the Washington Award Commission. He is a member of the Association of Iron and Steel Engineers, and the Illuminating Engineering Society.

H. B. Hansteen (A '26, M '43) formerly assistant professor of electrical engineering, College of the City of New York, N. Y., has been appointed associate professor of electrical engineering, at Cornell University, Ithaca, N. Y. Professor Hansteen holds the degree of electrical engineer (1924) from Polytechnic Institute of Brooklyn, and the degrees of master of arts (1929) and doctor of philosophy (1942) from Columbia University. He commenced his teaching career as instructor in mathematics at the Polytechnic Institute of Brooklyn, N. Y., in 1926. In 1929 he became an instructor at Columbia University, New York, and in 1930 returned to Polytechnic Institute of Brooklyn. He had been a member of the faculty of the College of the City of New York since 1937. Professor Hansteen was associated with the construction of the cyclotrons at Columbia University from 1935 to 1940 and with research on uranium fission under Professor Enrico Fermi. He also taught courses on radar and ultrahigh frequencies techniques for the United States Navy during the war. He is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

W. W. Lewis (A '09, F '38) formerly transmission engineer, central station engineering division, General Electric Company, Schenectady, N. Y., has been appointed professor of electrical engineering at Union College, Schenectady, N. Y. Born in Denver, Colo., Doctor Lewis received the degrees of bachelor of science in 1907, electrical engineer in 1923, and honorary doctor of science in 1936 from the University of Colorado. He was awarded the master of science degree by Union College in 1923. After completing the company test course at Schenectady, N. Y., in 1909, Doctor Lewis engaged in transmission engineering at the company's Pittsfield,

G. S. Whitlow

D. E. Moat

C. C. Wilson

Tomlinson Fort

Mass., plant until 1916, in which year he was transferred to the power and mining engineering department in Schenectady. In 1920 he was transferred to the lighting engineering department and since 1922 has been engineer in the central station division. He was sent to Japan and China in 1922 and to France, Italy, Germany, Belgium, and England in 1929. He is a member of CIGRE, the International Conference on Large Electric High-Voltage Systems, and Tau Beta Pi.

K. B. Aldrich (A '45) formerly chief, transmission development unit, Bonneville Power Administration, Portland, Oreg., recently was appointed director of the Arizona Power Authority, Phoenix. Mr. Aldrich received the degree of bachelor of science in electrical engineering from the University of Washington in 1922 and has been consulting engineer with many firms in Portland, Oreg., and Tacoma, Wash. He was dean of the engineering department of the evening session of Tacoma City College from 1922 to 1926, instructor in Oregon Institute of Technology from 1926 to 1928, and dean of higher mathematics in Portland City College in 1930. He was special agent for the division of investigation of the Public Works Administration from 1933 to 1937 and consultant to the Oregon State Hydroelectric Commission, and from 1938 to 1941 was research analyst for the Bonneville Power Administration. He became chief of transmission development in 1941. He is a member of the Electrochemical Society, the National Society of Professional Engineers, and the Professional Engineers of Oregon.

C. D. Lindridge (A '19, M '19) engineer with Bell Telephone Laboratories, Inc., New York, N. Y., recently completed 40 years of service with the Bell System. Other members of the laboratories who have completed 35 years of service are: **A. B. Clark** (M '19, F '30) vice-president; **J. W. Gooderham** (A '22, M '29) telephone engineer; **S. I. Cory** (A '24, M '31) of the systems department; **P. A. Jeanne** (A '20, M '30) member of the technical staff of the protection development department; **O. H. Loynes** (A '20); **R. G. McCurdy** (A '16, F '34) director of electrical apparatus development; and **Erich von Nostitz** (A '22). Those recently completing 25 years of service are: **G. H. Downes** (M '36); **B. F. Lewis** (A '38) research engineer; **M. S. Mason** (M '31) of the personnel department; and **E. R. Taylor** (A '24) of the systems development department. **D. S. Bender** (A '37, M '42) field engineer, Washington, D. C., has completed 20 years with the Laboratories, and **H. A. Stone, Jr.** (A '43) of the application and development department, ten years.

G. J. Taylor (M '44) formerly supervisory engineer, lamp department, General Electric Company, New York, N. Y., has become president of the newly organized company, Taylor-Light, Inc., North Hackensack, N. J. The firm will operate as a division of the Appleman Glass Works. Mr. Taylor holds the degrees of bachelor of science and electrical engineer from Illinois Institute of Technology and the degree of master of science from Massachusetts Institute of Technology. He entered the lighting industry as sales and service engineer for the General Electric Vapor Lamp Company, Chicago, Ill., in 1926. From 1928 to 1933 he was with the G. & W. Electric Specialty Company, Chicago. In 1939 he entered the lamp department of the General Electric Company, Cleveland, Ohio, as head of the industrial section of the engineering division. In 1942 he was appointed supervisory engineer for the New York area. Mr. Taylor is a member of the Illuminating Engineering Society, the National Society of Professional Engineers, and the Electrical and Gas Association of New York.

Harner Selvidge (A '39, M '45) a member of the staff of the applied physics laboratory of the Johns Hopkins University, Baltimore, Md., since 1941, has been appointed director of special products development for the Bendix Aviation Corporation and as such will co-ordinate company work on guided missiles and pilotless aircraft. Doctor Selvidge holds the degrees of bachelor and master of science from Massachusetts Institute of Technology and the degree of doctor of science from Harvard University. He has been instructor at Harvard University, Cambridge, Mass., and associate professor at Kansas State College, Manhattan, from which he was given leave of absence to join the staff of Johns Hopkins. He has been consulting engineer for Taylor Tubes, Inc., Chicago, Ill., and director of research for the American Phenolic Corporation, Chicago, since 1938. At Johns Hopkins University he worked on the proximity fuse, rugged vacuum tubes, and guided missile projects.

J. C. Wright (A '12) member of the technical staff, Bell Telephone Laboratories, Inc., New York, N. Y., has retired. Mr. Wright was graduated from Cornell University with the degree of mechanical engineer in 1909 and entered the student course of the Western Electric Company at Hawthorne, Ill. The following year he was transferred to the physical laboratories in New York and remained with the organization when it became Bell Laboratories. His work has lain in the field of transmission apparatus development, and he supervised development work on incandescent lamps and switchboard signaling. During World War II, Mr. Wright worked on the development of wire used in electronic equipment for the Armed Forces.

Robert Steck (A '03, M '13) administrative assistant to the engineer, Winter Street works, General Electric Company, Fort Wayne, Ind., has retired. Mr. Steck, who was graduated from the University of Michigan in 1898, commenced his career as an engineer in the apparatus department of the Western Electric Company, Chicago, Ill., in 1899. He became head of that company's d-c motor and generator section in 1905, and in 1909 when that section of the company was purchased by the General Electric Company he continued with the latter in Schenectady, N. Y. He was transferred to the company's Fort Wayne works in 1916 as engineer in charge of electric transmission. He was made head of design engineering of the farm power and light division in 1918, and executive engineer of the refrigeration division at the Winter Street works in 1924. Since 1931 he has been administrative assistant to the engineer in charge.

J. A. Cortelli (A '45) formerly chief engineer of commercial engineering, Clark Controller Company, Cleveland, Ohio, has been appointed chief engineer of the company. Mr. Cortelli was graduated from the Case School of Applied Science with the degree of bachelor of science in electrical engineering in 1928. Since that time, except for the year 1933 in which he was test engineer for Waite and Bartlett X-Ray Company, Cleveland, he has been with the Clark Company. He was engineer in the test, drafting, and engineering departments and in 1934 was named commercial engineer. **P. M. Christensen** (A '38, M '44) formerly research and development engineer, has been appointed manager of the development engineering department. A 1933 graduate of Trinity College, Mr. Christensen previously was chief engineer of the Colt Patent Fire Arms Manufacturing Company, Hartford, Conn. He joined the Clark Company in 1944.

F. T. Bear (A '23, M '31) formerly assistant electrical engineer, Delaware Power and Light Company, Wilmington, has been made chief engineer of the engineering department. A 1922 graduate of Pennsylvania State College, Mr. Bear was employed first by the Philadelphia (Pa.) Suburban Gas and Electric Company which later was absorbed by the United Gas Improvement Company. In 1928 Mr. Bear joined the Delaware company, and since 1945 he has been in charge of planning and supervising engineering development. **E. R. Streed** (A '33) engineer with the company since 1932 has been appointed assistant chief engineer. He is a 1931 graduate of Drexel Institute. **William Corrigan** (A '45) formerly relief system operator, has been appointed supervisor of system operation.

J. W. Latham (M '27) formerly chief engineer, Chesapeake and Potomac Telephone Company, Baltimore, Md., has been appointed assistant to the general manager. A graduate of the University of Virginia, Mr. Latham commenced his career with the Bell System in the engineering and installation departments of the Western Electric Company, Chicago, Ill., in 1906. He was assigned to the Southern Bell Telephone and Telegraph Company, Atlanta, Ga., in 1909, as engineer inspector and was made traffic supervisor at Charlotte, N. C., in 1910, and at Savannah, Ga., in 1912. He returned to Atlanta as traffic equipment engineer in 1913. Transferred to the Chesapeake and Potomac company in 1920, he was named facilities engineer in 1922 and was appointed chief engineer in 1929.

J. M. Wilson (A '23, M '33) formerly division manager, Virginia Electric and Power Company, Clifton Forge, Va., has been elected vice-president in charge of the western division of the company. Mr. Wilson's first utility position was that of superintendent for the Savannah (Ga.) Lighting Company in 1912, and in 1914 he joined the Virginia Western Power Company as local superintendent. During World War I he served with the United States Engineers and afterwards returned to the Virginia Western company as superintendent of its Hinton, W. Va., district. In 1924 he was made merchandising manager. He joined the Virginia Public Service Company, predecessor of the Electric and Power company, in 1928 as district manager.

Myron Zucker (A '27, M '36) engineer with Mackworth G. Rees, Inc., Detroit, Mich., since 1944, has been appointed a vice-president of the company. Born in New York, N. Y., in 1905, Mr. Zucker received the degree of electrical engineer from Cornell University in 1925 and the degree of master of science from Union University in 1927. He was associated with the General Electric Company, Schenectady, N. Y., from 1925 to 1929, working on testing, thyratron application development, and central station engineering. In 1929 he entered the engineering division of the Detroit Edison Company. He is a member of the Engineering Society of Detroit.

Bertram Wellman (A '26) formerly development engineer, Photoswitch, Inc., Cambridge, Mass., is president of the Electrodyne Company, Boston, Mass., a newly formed corporation. Mr. Wellman, who received the bachelor of science degree in 1924 from Harvard University and the master of science degree in 1937 from Massachusetts Institute of Technology, was associated with the research laboratory of the General Electric Company, Schenectady, N. Y., until 1932. He became research associate in psychology at the University of Rochester in 1937 and assistant director of the research laboratory of sensory psychology and physiology at Tufts College, Medford, Mass., in 1938.

W. J. Ellenberger (A '31, M '38) recently released from duty with the Signal Corps as a lieutenant colonel, has been appointed plant superintendent at the National Bureau of Standards, Washington, D. C. From 1942 until his release from active duty, Mr. Ellenberger served in the Signal Corps first as executive officer, Resources Branch, Office of the Chief Signal Officer; later as chief of the Signal Section, International Division, Army Service Forces; and most recently as assistant executive, United States Staff, London Munitions Assignment Board. He was awarded the Army Commendation Ribbon and the Order of the British Empire for his services in connection with military lend-lease.

H. W. Biskeborn (M '39) formerly chief engineer, Phillips Electrical Works, Ltd., Brockville, Ontario, Canada, recently joined the Canadian Comstock Company, Montreal, Quebec, Canada. Born in Hanover, Germany, in 1898, Mr. Biskeborn was graduated from the Polytechnic School of Engineering in 1917. From 1919 to 1938 he was associated with various English firms: the Hart Accumulator Company, Ltd., London; the British Electric Transformer Company, Ltd., Middlesex; the Hackbridge Electric Construction Company, Ltd. Waltham-on-Thames; and Crompton Parkinson, Ltd., Chelinsford. In 1938 he returned to Canada, where in 1930 he had organized the Hackbridge Transformer Company of Canada, as electrical and development engineer for the Phillips Works.

P. E. Shaad (A '34, M '46) formerly plant engineer, Spreckels Sugar Company, Woodland, Calif., has been appointed chief electrical engineer of the Sacramento (Calif.) Municipal Utility District. The electric distribution system for which Mr. Shaad is responsible is being purchased from the Pacific Gas and Electric Company effective December 31, 1946. Mr. Shaad was graduated from the University of Kansas with the degree of electrical engineer for 1933. From 1933 to 1940 he was associated with the General Electric Company, Schenectady, N. Y., and San Francisco, Calif., engaging in steam turbine testing, industrial control design, commercial engineering, and field engineering. He was sent to Hawaii to survey sugar plantations in 1938 and in 1940 became electrical engineer for the Hawaiian Electric Company, Ltd., Honolulu. He returned to California in 1944 to become plant engineer for the Spreckels company. Mr. Shaad is a member of Tau Beta Pi, Sigma Tau, and the National Society of Professional Engineers.

Alexander Maxwell (F '37) director of engineering, Edison Electric Institute, New York, N. Y., has retired. Mr. Maxwell was born in New York in 1878. From 1895 to 1924 he was associated with the New York Edison Company and its predecessors as assistant superintendent of operation. In 1924 he joined the staff of the National Electric Light Association, and, when that organization was dissolved in 1933, he became director of engineering for the Edison Electric Institute. Mr. Maxwell served in the Field Artillery in World War I and was discharged from service as a lieutenant colonel. He has served as chairman of the AIEE committees on Standards and domestic and commercial applications and as chairman of the board of examiners.

W. A. Lewis, Jr. (A '27, F '45) research professor of electrical engineering at Illinois Institute of Technology and consultant to the institute's Armour Research Foundation has been appointed dean of the institute's graduate school. Doctor Lewis received the degrees of bachelor of science in 1926, master of science in 1927, and doctor of philosophy in 1929 from the California Institute of Technology. Until 1939 he was central station engineer with the Westinghouse Electric Corporation, East Pittsburgh, Pa., and that year was appointed director of the school of engineering at Cornell University, Ithaca, N. Y. He joined the faculty of the Illinois Institute of Technology in 1944.

Frank Noakes (A '41) formerly assistant research engineer with the Hydro-Electric Commission of Ontario, Toronto, Canada, has been appointed associate professor of electrical engineering at the University of British Columbia, Vancouver. Doctor Noakes holds the degree of bachelor of science (1937) from the University of Alberta and the degrees of master of science and doctor of philosophy from Iowa State College. He was a graduate teaching and research assistant at Iowa State College, Ames, from 1937 to 1940 and a lecturer at the University of Toronto from 1940 to 1943. Since 1943 he has been with the Hydro-Electric Commission.

E. J. Butler (A '30) formerly electrical engineer, Western Electric Company, Inc., Kearny, N. J., has joined the faculty of the Thayer School of Engineering, Dartmouth College, Hanover, N. H., as assistant professor of engineering and management. Professor Butler was graduated from Rutgers University with the degree of bachelor of science in 1924 and after a brief association with the Westinghouse Electric Corporation, East Pittsburgh, Pa., became assistant power engineer with the New York and Queens Electric Light and Power Company, Long Island City. He was titled commercial engineer in 1929 and manager of the commercial engineering bureau in 1935. During the war Mr. Butler was with the Western Electric Company and the Raytheon Company on special communications assignments.

J. K. Nunan (A '39) West Coast manager of professional motion picture sales, Ansco division, General Aniline and Film Corporation, Los Angeles, Calif., recently was awarded the Navy Medal for Merit. The award was in recognition of his wartime services as assistant resident director of the New London (Conn.) Laboratory and director of the Pearl Harbor division of the Columbia University Division of War Research. Mr. Nunan is a graduate of the University of Southern California, and a former professor at the University of Southern California and the California Institute of Technology.

O. E. Buckley (M '19, F '29) president, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed a member of a special Advisory Committee on Ordnance Research and Development formed by the Army Ordnance Association. Doctor Buckley also has been awarded the Medal for Merit. The citation accompanying the award read: "He displayed great foresight by expediting development . . . even before its military value had become apparent, and his leadership was reflected in the highly effective collaboration of scientists and technicians who overcame extremely complex problems in the development of new electronic techniques essential to success."

G. W. Douglass (M '32) formerly engineer of exchange plant extension, New Jersey Bell Telephone Company, Newark, has been appointed chief engineer of the company. Mr. Douglass was graduated from the Polytechnic Institute of Brooklyn in 1909 and in 1910 became an engineering assistant with the New York Telephone, New York. In 1925 he was made engineer of exchange plant extension for the New Jersey area of the company and in 1927 was transferred to the New Jersey company in that capacity.

W. B. Beals (A '09, M '27) staff engineer, Chesapeake and Potomac Telephone Company, Washington, D. C., has retired. Born in Norwich, N. Y., in 1881, Mr. Beals earned the degree of mechanical engineer from Cornell University in 1902. He joined the Baltimore division of the Chesapeake and Potomac Telephone Company in 1904. In 1912 he was transferred to Washington, and in 1913 was named outside plant engineer. He became transmission and protective engineer in 1928 and staff engineer in 1929.

C. M. Fulk (A '16) electrical engineer, central station engineering division, apparatus department, General Electric Company, Schenectady, N. Y., has retired. Born in 1881, Mr. Fulk was graduated from Purdue University in 1907 with the degree of bachelor of science in electrical engineering. Immediately after graduation he entered the test course of the General Electric Company and from 1917 to 1922 was assigned to d-c design and field engineering in the New York, N. Y., office of the company. Since 1922 he has been engaged in application engineering with the central station division in Schenectady.

Frank Breckenridge (M '43) formerly chief engineer, home appliance division, Federal Telephone and Radio Corporation, Newark, N. J., is now vice-president and chief engineer of the Automatic Washer Company, Newton, Iowa. Mr. Breckenridge previously had been associated with the Automatic Washer Company from 1929 to 1932. Since that time he has been associated variously with the One Minute Manufacturing Company, Newton; the Conlon Corporation, Chicago, Ill.; and the Westinghouse Electric and Manufacturing Company, Mansfield, Ohio.

B. A. Fisher (M '45) formerly in charge of graduate work in electronics and communications at Oklahoma Agricultural and Mechanical College, Stillwater, has been appointed professor of electrical engineering at the University of Denver, Colo. Professor Fisher received the bachelor of science degree from the University of Missouri in 1924 and the master of science degree from Harvard University in 1937. Previously associated with the University of Nevada and South Dakota State College, Professor Fisher recently served in the United States Naval Reserve as lieutenant commander and instructor in electrical engineering at the United States Naval Academy, Annapolis, Md.

E. S. Lee (A '20, F '30) engineer in charge of the General Electric Laboratories, Schenectady, N. Y., recently made a one-month tour of electrical manufacturing companies in England and France to discuss developments in engineering and science. While in France, Mr. Lee attended the Paris meeting of the International Technical Congress and from September 22 to 29 acted as official AIEE delegate to the sixth Industrial Congress for Applied Mechanics in Paris.

G. F. Crowell (A '20, F '42) formerly chief engineer, Wisconsin Telephone Company, Milwaukee, has been elected a vice-president of the company. After a brief period with the Yarmouth (Nova Scotia, Canada) Telephone Company, Mr. Crowell entered the plant department of the Wisconsin Telephone Company in 1906. He was assigned to central office equipment engineering in 1912 and named transmission and protection engineer in 1917. He has been chief engineer of the company since 1928.

C. H. Giroux (M '25, F '44) special assistant to the Chief of Engineers, Washington, D. C., recently was awarded the Exceptional Civilian Service Medal for his services during World War II. During the war, Mr. Giroux, who has been with the War Department since 1923, acted as consultant in connection with power supply to war industries and assisted in the development and utilization of power equipment for the Armed Forces. He also served as consultant to the Manhattan District.

W. L. Rubel (M '39) formerly captain, United States Naval Reserve, on the staff of the Production Officer, New York Naval Shipyard, has joined the firm of Guy B. Panero, New York, N. Y., as an associate in charge of the industrial and power division. Mr. Rubel previously was associated with Sanderson and Porter, New York, and was chief engineer of the Memco Engineering and Manufacturing Company, Long Island City, N. Y.

W. R. Whitney (A '01) vice-president in charge of research, General Electric Company, Schenectady, N. Y., recently received the first Industrial Research Institute Medal "for his outstanding contributions to the field of industrial research as a distinguished scientist, a pioneer of industrial research, and a leader and molder of men."

W. S. Hill (A '25, M '30) formerly assistant district engineer, General Electric Company, Buffalo, N. Y., has been appointed to the recently created post of manager of engineering of the Locke Insulator Corporation, Baltimore, Md. All engineering activities consisting of ceramic, design and development, and requisition engineering have been combined into one engineering department which will be managed by Mr. Hill. Mr. Hill was graduated from the University of Nevada.

G. D. McCann (A '38, M '44) formerly transmission engineer, industry engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed associate professor of electrical engineering at California Institute of Technology, Pasadena. Further biographical details on Doctor McCann can be found in the July issue of *Electrical Engineering*, page 355.

M. J. Smith (A '38) formerly instructor at Rice Institute, Houston, Tex., has been appointed assistant professor of electrical engineering at the University of Colorado, Denver. Professor Smith was graduated from Rice Institute in 1931 and was instructor at the University of Colorado from 1941 to 1943.

T. M. Odarenko (M '42) products line manager, Federal Telephone and Radio Corporation, Clifton, N. J., has been assigned to direct an investigation of special developments in the German communications industry of interest to American manufacturers. His report will be made available through the Office of the Publication Board, United States Department of Commerce.

J. B. Moore (M '41) formerly of the plant design engineering department, RCA Communications, Inc., New York, N. Y., was assigned to the Far East in May to assist General MacArthur's Civil Communications Section. Mr. Moore has been with RCA since 1922, when he entered the company's employ as a receiving engineer.

J. W. McRae (A '37) electrovisual engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed director of radio projects and television research for that organization. Doctor

McRae became affiliated with Bell Laboratories at Deal, N. J., in 1937. During the war he served as a colonel in the Signal Corps.

A. W. K. Billings (A '07, F '13) president, Brazilian Traction, Light and Power Company, Ltd., Rio de Janeiro, has been awarded the National Order of the Southern Cross, highest civilian decoration of the Government of Brazil in recognition of his development of hydroelectric resources in the Sao Paulo–Rio de Janeiro area.

E. F. Pearson (M '20, F '37) formerly assistant to the vice-president and general manager, Northwestern Electric Company, Portland, Oreg., has been appointed assistant general manager with offices in Vancouver, Wash. Mr. Pearson has been with the Northwestern company for 34 years, and he has been assistant to the general manager since 1935.

Elliot Ginochio (A '45) formerly industrial power engineer, Pacific Gas and Electric Company, Sacramento, Calif., has been appointed sales manager of the Shasta division of that company. Mr. Ginochio has been associated with the Pacific Gas and Electric Company since 1929.

H. E. Ellis (A '31, M '42) formerly electrical design engineer, Westinghouse Electric Corporation, Lima, Ohio, has been appointed chief engineer of Electro Machines, Inc., Cedarburg, Wis. Mr. Ellis had been with the Westinghouse company for 17 years.

Carl Whitmore (A '18) president of the New York Telephone Company, N. Y., has received a War Department Certificate of Appreciation in recognition of his services in "providing communications facilities to Army installations. . . and for expert assistance in the establishment of aircraft warning systems."

W. T. Johnson (A '39) formerly assistant to the general superintendent, California Electric Power Company, Riverside, has been appointed general superintendent. Mr. Johnson joined the company in 1924 as superintendent at Yuma, Ariz., and district superintendent of operations in the Imperial Valley, Calif.

V. G. Muzsnay (A '38) formerly assistant engineer, Puget Sound district, Bonneville Power Administration, Seattle, Wash., has been transferred to the Portland engineering division. **J. V. Lamson** (A'29, M '42) formerly district engineer for the Administration at Portland has replaced Mr. Muzsnay.

Harvey Fletcher (M '23, F '30) director of physical research, Bell Telephone Laboratories, Inc., New York, N. Y., has been made a member of the committee on John J. Carty Fund of the National Academy of Sciences for a term of five years.

J. F. Gogins (A '40) formerly general manager of the Spokane, Wash., office of the General Electric Company has been made assistant district sales manager for the entire Pacific Northwest and Alaska. His headquarters will be in Portland, Oreg.

C. B. McCartney (A '43) superintendent of transmission and distribution, Florida Power Corporation, St. Petersburg, has resigned to become a consulting engineer. He was graduated from the Milwaukee School of Engineering in 1924.

E. I. Pollard (A '35, M '45) has been appointed engineering manager of the Elliott Company's Ridgway (Pa.) division. Mr. Pollard, who joined the company earlier this year, previously was associated with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

T. C. Clarke (A '35, M '42) district manager, Northern Electric Company, Ltd., Vancouver, British Columbia, Canada, has been appointed a director of the Langley Manufacturing Company, Ltd., Vancouver, and the Langley Electrical Company, Ltd., Calgary.

J. H. Polhemus (M '40) president, Portland (Oreg.) General Electric Company, was elected president of the Northwest Electric Light and Power Association at the annual meeting held recently in Seattle, Wash.

R. P. Glover (M '45) consulting engineer, Oak Park, Ill., has been appointed technical representative in the Chicago area by Technology Instrument Corporation, Waltham, Mass.

W. L. Hetherington (A '40) formerly engineer, Steel Company of Canada, Montreal, Quebec, is now with the Packard Electric Company, St. Catharines, Ontario, Canada.

J. W. Lingary (M '32) superintendent of electric plant, Lynn (Mass.) Gas and Electric Company, has been elected chairman of the New England System Operators Club.

E. C. Crittenden (A '19, F '44) associate director, National Bureau of Standards, Washington, D. C., has been elected a member of the International Committee on Weights and Measures. Doctor Crittenden recently was awarded the honorary degree of doctor of science by the Case School of Applied Science.

G. M. Heinze (A '37) formerly assistant engineer, electrical engineering department, New York, New Haven, and Hartford Railroad, New Haven, Conn., has been named electrical supervisor.

L. F. Greve (M '38) electrolysis engineer, Commonwealth Edison Company, Chicago, Ill., has been elected chairman of the newly formed North Central regional division of the National Association of Corrosion Engineers.

H. B. Waters (A '04) formerly president, Telluride Power Company, Salt Lake City, Utah, has been elected chairman of the board for the company.

W. V. Kahler (M '39) vice-president in charge of operation, Illinois Bell Telephone Company, Chicago, has been elected chairman of the Washington Award Commission for 1946–47.

M. J. McHenry (A '11, M '20) director of promotion, Hydro-Electric Power Commission of Ontario, Toronto, Canada, has been elected president of the Electric Service League of Ontario.

E. O. Slaybaugh (M '43) formerly assistant division superintendent, Consumers Power Company, Battle Creek, Mich., has been appointed division superintendent.

P. Dunsheath (M '22) director and chief engineer, W. T. Henley's Telegraph Works Company, Ltd., London, England, has been elected honorary secretary of the International Electrotechnical Commission.

OBITUARY • • • •

Frank Ambler Pattison (A '91, M '91, F '13) consulting engineer and retired member of the firm, Pattison Brothers, New York, N. Y., died September 18, 1946. Mr. Pattison, who was born in New York, December 10, 1867, was graduated from Rutgers College in 1887 with the degree of bachelor of arts. He received the degree of master of arts in 1890. Before entering college he spent some time experimenting at the Edison works in Menlo Park, N. J. After brief employment with the Edison Electric Company of New York and the Edison Electric Illuminating Company of New Orleans, La., he opened his own consulting office in New York. In 1891 he and his brother founded the firm of Pattison Brothers which was continued until Mr. Pattison retired in 1937. The firm planned the electrical, mechanical, heating, and ventilating systems for many well-known buildings in New York, among them museums, hotels, the stock exchange, banks, insurance companies, newspapers, and private residences. The firm also worked on the stock exchange in Montreal, Quebec, Canada, and insurance company buildings in Boston, Cleveland, Newark, Providence, and Springfield, Mass. Mr. Pattison had served on the AIEE committee on safety codes. In 1916 he was a delegate to the Progressive National Convention and in 1924 was a member of the committee which supported Senator Robert M. LaFollette, Sr., for President. He was a member of the American Society of Mechanical Engineers, and the Engineers Club of New York.

James Enon Macdonald (A '03, M '13) retired secretary, Joint Pole Committee, Los Angeles, Calif., died August 8, 1946. Mr. Macdonald, who was born in New Glasgow, Nova Scotia, Canada, October 27, 1874, was graduated from McGill University with the degree of bachelor of science in 1897. After graduation he was draftsman with Brown and Sharpe Manufacturing Company, Providence, R. I., in 1897 and 1898 and with the William Sellers Company, Philadelphia, Pa., in 1899. He went to Los Angeles in 1900 as draftsman for the Baker Iron Works. Entering the employ of the Pacific Electric Railway Company, Los Angeles, in 1902, he became successively electrician, foreman, engineer in charge of electrical testing, and assistant electrical engineer. In 1907 he was appointed secretary of the Joint Pole Committee formed in Los Angeles by four railways and three electric companies to bring about the common use of poles on a joint ownership basis. At the time of Mr. Macdonald's retirement in 1940, the committee's membership had grown to 28 utilities whose scope of operation covers most of Southern California and part of the San Joaquin Valley. Mr. Macdonald served as an AIEE vice-president for 1923–25 and was one of the group which organized the Los Angeles Section of the Institute. He had served on the AIEE committees on Sections, membership, and meeting and papers. He was president of the Los Angeles Engineering Council for 1934–35.

Louis Frederick Blume (A '09, M '34, F '39) retired assistant engineer, transformer engineering department, General Electric Company, Pittsfield, Mass., died August 14, 1946. Born in Philadelphia, Pa., November 14, 1882, Mr. Blume received the degree of electrical engineer from Lehigh University in 1905 and the degree of master of arts from Cornell University in 1909. He was instructor in the Lowell (Mass.) Textile High School in 1906 and 1907 and at Cornell University from 1907 to 1909. He entered the employ of the General Electric Company at Pittsfield in 1909 as designer in the transformer engineering department and in 1926 was named assistant engineer. He received the Coffin Award in 1924 for development of a method of regulating transformer voltage and again in 1929 for the development of nonresonating transformers. Mr. Blume was the author of a number of technical papers and was the editor and coauthor of "Transformer Engineering." He was granted more than 20 patents. He served on the AIEE committee on Standards from 1915 to 1922.

William F. Filer (M '26) switching development engineer, Bell Telephone Laboratories, Inc., New York, N. Y., died June 24, 1946. He was born November 8, 1888, in Hilton, N. Y., and attended Pratt Institute. Mr. Filer entered the employ of the Western Electric Company in 1906 and was assigned to installation work in the West and Southwest. In 1911 he was assigned to the circuit laboratory in New York and in 1915 was made supervisor of the development of manual telephone circuits. During World War I he was in charge of a group on Army and Navy work. He was made supervisor of development for both manual and automatic telephone systems in 1922. After 1925 he continued with this work with Bell Telephone Laboratories. During the recent war he supervised the circuit development for the Army's air warning network and also did much work for the Civil Aeronautics Administration.

William Lester Dively (A '27) district representative, Century Electric Company, Buffalo, N. Y., died recently. Mr. Dively was born October 6, 1900, in Claysburg, Pa., and was graduated from the University of Pittsburgh with the degree of bachelor of science in electrical engineering. He joined the Century company in St. Louis, Mo., in 1925 and was transferred to Philadelphia the following year. He became company representative at Buffalo in 1940.

MEMBERSHIP ••

Recommended for Transfer

The board of examiners, at its meeting of September 19, 1946, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Bibber, H. W., chairman, div. of engg., and prof., elec. engg., Union College, Schenectady, N. Y.
Carpenter, J. W., pres. & general mgr., Texas Pr. & Lt. Co., Dallas, Tex.
Daly, C. J., trans. & outside plant engr., Southern New England Tel. Co., New Haven, Conn.
Demuth, O. A., chief, systems engg. staff, Bonneville Pr. Adm., Portland, Oreg.
Dillard, E. W., elec. engr., New England Pr. Service Co., Boston, Mass.
Hamilton, R. F., elec. engr., P-8, U. S. Civil Service, Washington, D. C.
Jump, G. H., dist. engr., General Elec. Co., Boston, Mass.
Love, N. R., chief engr., Denver Tramway Corp., Denver, Colo.
Lowenberg, M. J., sr. elec. engr., Stone & Webster Engg. Corp., Boston, Mass.
Pettee, A. D., chief engr., General Cable Corp., New York, N. Y.
Polhemus, J. H., pres., Portland General Elec. Co., Portland, Oreg.
Ports, E. G., technical director, radio div., Federal Tel. & Radio Corp., Newark, N. J.
Stafford, R. T., mgr., transformer sec., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Stewart, H. R., protection engr., New England Pr. Service Co., Boston, Mass.

14 to grade of Fellow

To Grade of Member

Alfers, J. B., elec. engr., Navy Dept., Bureau of Ships, Washington, D. C.
Anderson, R. E., distribution engr., Southwestern Gas & Elec. Co., Marshall, Tex.
Asbury, C. E., elec. engr., Commonwealth & Southern Corp., Jackson, Mich.
Bailey, A. D., ass't prof., elec. engg., Univ. of Illinois, Urbana, Ill.
Bauer, J. L., application engr., ind. engr. divs., General Elec. Co., Schenectady, N. Y.
Beale, R. L., div. engr., Texas Elec. Service Co., Big Spring, Tex.
Becker, H. W., electronics instructor, Mare Island Fire Control School, Mare Island, Calif.
Bourne, R. F., engg. representative, Colorado Fuel & Iron Corp., Denver, Colo.
Bowman, J. F., elec. engr., Fisk tire plant, U. S. Rubber Co., Chicopee Falls, Mass.
Brannan, A. I., chief elec. engg., Mene Grande Oil Co., western div., Maracaibo, Venezuela, S. A.
Bruun, S. W., illuminating & designing engr., Rambusch Decorating Co., New York, N. Y.
Burrell, K. H., ind. control specialist, General Elec. Co., Cleveland, Ohio.
Castonguay, W. R., service engr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Clatterbaugh, F. C., instructor, Iowa State College, elec. engg. dept., Ames, Iowa.
Cunningham, J. C., Jr., elec. aviation application engr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Davenport, H. H., engineer, Southwestern Bell Tel. Co., Dallas, Tex.
del Busto, A. F., ass't supt., transm. & dist., Mexican Lt. & Pr. Co., Ltd., Mexico, D. F., Mexico.
Dillingham, H. C., prof. of elec. engg., A & M College of Texas, College Station, Tex.
Duphorne, H. M., inventory & costs engr., Southwestern Bell Tel. Co., St. Louis, Mo.
Edwards, R. F., design engineer, Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Eichhorn, C. W., design engr., Raytheon Mfg. Co., Waltham, Mass.
Fain, J., control engineer, Public Service Elec. & Gas Co., Newark, N. J.
Fenlon, D. R., sr. engr., Turf Development Board, Dublin, Ireland.
Fister, E. J., elec. engr., Signal Corps engg. labs., Evans Signal Lab., Belmar, N. J.
Fouracre, V. W. M., manager, Barvic Engineering, Ltd., Vancouver, British Columbia, Canada.
Fowler, W. K., manager for Far East, apparatus div., International General Elec. Co., Schenectady, N. Y.
Franklin, J. S., engr., lighting div., General Elec. Co., West Lynn, Mass.
Friel, A. C., elec. engr., Dow Chemical Co., Midland, Mich.
George, R. H., research prof., elec. engg. div., Purdue Univ., Lafayette, Ind.
Goodheart, C. F., ordnance engr., Naval Gun Factory, Naval Ordnance Lab., Washington, D. C.
Gorman, W. J., div. working practices supv., American Tel. & Tel. Co., Philadelphia, Pa.
Hale, P. W., ass't engr., Consolidated Edison Co. of New York, Inc., New York, N. Y.
Hall, W. M., radio engineer, Raytheon Mfg. Co., Waltham, Mass.
Higgins, T. J., associate prof., elec. engg., Illinois Institute of Technology, Chicago, Ill.
Hoyt, T. C., elec. engr., Ebasco Services, Inc., New York, N. Y.
Hutloff, E. W., elec. designer & div. head, Public Service Elec. & Gas Co., Newark, N. J.
Joyner, K. O., elec. engr., National Advisory Comm. for Aeronautics, Langley Field, Va.
Liensch, J. P., development engr., Foxboro Co., Foxboro, Mass.
Loeffler, H. F., co-ordination engr., Wisconsin Tel. Co., Milwaukee, Wis.
Louret, H. A., sr. engr., engg. dept., Commonwealth Edison Co., Chicago, Ill.
Malone, Jr., C., elec. engr., Hazel-Atlas Glass Co., Wheeling, W. Va.
Michaels, H. J., design engr., Allis-Chalmers Mfg. Co., West Allis, Wis.
Michel, M., elec. engr., Aluminum Co. of America, Pittsburgh, Pa.
Miller, G. W., chief engr., Rochester Tel. Corp., Rochester, N. Y.
Miller, J. B., retired, 200 Masonic Bldg., Oregon City, Oreg.
Monteith, C. D., elec. engr., c/o National Park Service, Chicago, Ill.
Murphy, E. K., district engr., Westinghouse Elec. Corp., New York, N. Y.
Murphy, H. E., engr., General Electric Co., New York, N. Y.
Nelson, N. H., project mgr., G. B. Conner's & Co., Hollywood, Calif.
Nicholson, A. J., elec. engr., Kansas City Pr. & Lt. Co., Kansas City, Mo.
Raine, R. W., elec. designer, partner, Edward D. de Luca & Associates, So. Jacksonville, Fla.
Rettig, V. G., elec. planning engr., Cincinnati Gas & Elec. Co., Cincinnati, Ohio.
Roldan G, D., technical director, Industrias Uhidas, S. A., Mexico, D. F., Mexico.
Rollins, C. A., ass't engr., Headman, Ferguson & Carollo, Phoenix, Ariz.
Rouault, C. L., prof. cons. engr., 704 Oak St., Syracuse, N. Y.
Schuster, E. F., ass't elec. engr., Underwriters' Laboratories, Inc., New York, N. Y.
Seifried, A. G., chief elec. engr., machine develop. dept., B. F. Goodrich Co., Akron, Ohio.
Seitz, R. M., elec. engr., Eastman Kodak Co., Rochester, N. Y.
Shallenberger, J. W., consulting elec. engr., 886 Main St., Bridgeport, Conn.
Shaw, Jr., M. R., research engr., physical lab., Corning Glass Works, Corning, N. Y.
Smith, Jr., H. M., application engr., Westinghouse Elec. International Co., New York, N. Y.
Stauffer, J. L., division engr., lines & stations, Pa. Pr. & Lt. Co., Lancaster, Pa.
Summers, S. D., elec. engr., staff consultant, aircraft electrical div., Naval Research Lab., Washington, D. C.
Taragin, S., elec. engr., Aberdeen Proving Grounds, Md.
Taylor, R. H., ass't engr., Narragansett Elec. Co., Providence, R. I.
Turner, Jr., R. C., commander, U. S. Naval Reserve, U. S. Naval Academy, Annapolis, Md.
Wainwright, R. M., research engr., Montana–Dakota Utilities Co., Glendive, Mont.
Westin, L. J., power plant engr., Day & Simmerman, Inc., Philadelphia, Pa.
Williams, H. E., vice-pres., Knox Porcelain Corp., Knoxville, Tenn.
Williams, S. B., research engr., Mass. Inst. of Tech., Cambridge, Mass.
Williges, J. A., engr., Hamilton & Williges, Oakland, Calif.

Wilson, N. E., Westinghouse fellow, Illinois Inst., of Tech., Chicago, Ill.
Witty, B. G., office & field engr., Allis-Chalmers Mfg. Co., Chicago, Ill.
Worcester, W. G., engr., General Elec. Co., Schenectady, N. Y.

74 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before November 21, 1946, or January 21, 1947, if the applicant resides outside of the United States or Canada.

To Grade of Member

Batzold, H. A., General Elec. Co., New York, N. Y.
Bird, G. T., University of Houston, Houston, Tex.
Blagg, S. M., Lt. Col., Royal Engineers, British Army, Sialkot, Punjab, India.
Blankenship, N., General Elec. Co., Dallas, Tex.
Boone, J. J., American Tel. & Tel. Co., Philadelphia, Pa.
Brownlee, A. L., Wico Elec. Co., W. Springfield, Mass.
Buttloph, M. D., Army Transportation Corps Board, Brooklyn, N. Y.
Campbell, D. L., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Clark, E. W., General Elec. Co., West Lynn, Mass.
Daniel, C. E., 325 N. Charles St., Baltimore, Md.
DeBaugh, R., U. S. Naval Shipyard Terminal Island, San Pedro, Calif.
DeWalt, K. C., General Elec. Co., Schenectady, N. Y.
Doll, H. F., Victor Elec. Products, Inc., Cincinnati, Ohio.
Erikson, B. W., General Elec. Co., Schenectady, N. Y.
Fleming, T. M., Kentucky Utilities Co., Lexington, Ky.
Garber, L. H., American Tel. & Tel. Co., Chicago, Ill.
Gostyn, E., F. W. Sickles Co., Chicopee, Mass.
Henderson, S. F., Westinghouse Elec. Corp., Buffalo, N. Y.
Hughes, M. R., Ulteig Engg. Co., Fargo, N. D.
Jackson, G. C. R., Major, Canadian Vocation Training Electrical School, Vancouver, B. C., Canada.
Kucera, C. F., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Longenecker, D. M., General Elec. Co., West Lynn, Mass.
Lowe, J. T., Bell Tel. Labs., Inc., New York, N. Y.
McKenna, A. T., North Wales Power Co., Ltd., Wrexham, North Wales, Great Britain.
McNutt, J., James Lees & Sons Co., Bridgeport, Pa.
Mincho, C. H., Harrisburg Steel Corp., Harrisburg, Pa.
Morales S., E., Agent-Holophane Co., Inc. of N. Y., Mexico, D. F., Mexico.
Myers, F. H. E., The British Thomson-Houston Co., Ltd., Rugby, England.
Paden, T. L., Pennsylvania Power Co., New Castle, Pa.
Roy, L., Quebec Hydro-Elec. Comm., Montreal, Que., Canada.
Slattery, J. J., Signal Corps Engg. Labs., Bradley Beach, N. J.
Stevens, H. B., Westinghouse Elec. Corp., Panama, R. P.
Warner, N. A., N. Y. Tel. Co., New York, N. Y.

33 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Blumenauer, C. E., U. S. Rubber Co., Chicopee Falls, Mass.
Campbell, H. E., General Elec. Co., Schenectady, N. Y.
Cohrs, W. C., Eastman Kodak Co., Rochester, N. Y.
Folsom, E. E., Jr., General Elec. Co., Bridgeport, Conn.
Hartshorn, J. A., New England Gas & Elec. Association, Cambridge, Mass.
Prybyla, J. J., Blackstone Valley Gas & Elec. Co., Pawtucket, R. I.
Rutecki, J. E., 84 Sassamon Ave., Milton, Mass.
Smet, J. E., Allis-Chalmers Mfg. Co., Boston, Mass.

2. Middle Eastern

Beasley, B. T., U. S. Naval Ordnance Plant, South Charleston, W. Va.
Beiler, A. C., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Biles, A. E., Hartford Steam Boiler Insp. & Ins. Co., Cleveland, Ohio.
Boenning, C. B., The Johns Hopkins University, Baltimore, Md.
Deveney, A. B., Philadelphia Elec. Co., Philadelphia, Pa.
Eidson, L. U., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Femiano, D., Potomac Elec. Power Co., Washington, D. C.
Graber, R. P., Koppers Co., Inc., Newport, Del.
Grubb, R. K., Delaware Pr. & Lt. Co., Wilmington, Del.
Higgins, C. F., Nat'l. Advisory Comm. of Aeronautics, Cleveland, Ohio.
Hutchins, J. L., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Johnson, E. F., Clark Controller Co., Cleveland, Ohio.
Kissel, J. (re-election), Rural Electrification Administration, Washington, D. C.
Lee, W. A., Jr., Westinghouse Elec., East Pittsburgh, Pa.
Lusk, R. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Magee, W. P., Philadelphia Elec. Co., Philadelphia, Pa.
Mandris, T. L., David Taylor Model Basin, Washington, D. C.
Michels, W. G., Division of Lt. & Pr., Cleveland, Ohio.
Puette, R. L., The Clark Controller Co., Cleveland, Ohio.
Scholze, E. T., Westinghouse Elec. Corp., Cleveland, Ohio.
Stewart, C. F., Carbide & Carbon Chemicals Corp., South Charleston, W. Va.
Szabo, E. J., Jr., Leece-Neville Co., Cleveland, Ohio.
Tarn, L. W., Bell Tel. Co. of Pa., Pittsburgh, Pa.
Wellens, H. E., Otis Elevator Co., Philadelphia, Pa.
Yeide, H. E., Potomac Elec. Pr. Co., Washington, D. C.

3. New York City

Adams, W. F., N. Y. State Public Service Comm., New York, N. Y.
Bruhn, N., N. Y. City Bd. of Transportation, New York, N. Y.
Chan, W. W., Sperry Gyroscope Co., Inc., Garden City, N. Y.
Di Sesa, L. E., Otis Elevator Co., Yonkers, N. Y.
Faulkner, F. K., Public Service Elec. & Gas Co., Newark, N. J.
Ferber, A. H., N. J. Bell Tel. Co., Morristown, N. J.
Ferrier, L. H., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Heymont, L., American Gas & Elec. Service Corp., New York, N. Y.
Hollenback, L. E., Veterans Administration, Northport, N. Y.
Lanigan, C. E., Sperry Gyroscope Co., Garden City, N. Y.
Lawrence, N. S., 170 Lincoln Ave., Newark, N. J.
Loock, G. E., American District Teleg. Co., New York, N. Y.
Mann, J., 4 Park Place, Hempstead, N. Y.
Maury, E. S., Lt., SCEL, Fort Monmouth, N. J.
McQuade, F. J., Board of Transportation, New York, N. Y.
Miles, R. A., 407 East 69 Street, New York, N. Y.
Preuss, J. (re-election), Consolidated Edison Co. of N. Y., New York, N. Y.
Royer, C. E., Sperry Gyroscope Co., Inc., Great Neck, N. Y.
Scott, W. S., American Gas & Elec. Service Corp., New York, N. Y.
Stone, E. P., SCEL, Fort Monmouth, N. J.
Warren, H. H., The Elec. Storage Battery Co., New York, N. Y.

4. Southern

Best, E. J., Southwestern Gas & Elec. Co., Shreveport, La.
Cahn, A. S., Cahn Elec. Co., Shreveport, La.
Cambias, S., Jr., Mississippi Valley Elec. Co., New Orleans, La.
Cavanaugh, J. W., 4729 Baronne St., New Orleans, La.
Cochran, W. A., Jr., Alabama Power Co., Birmingham, Ala.
Early, E. D., Commonwealth & Southern Corp., Birmingham, Ala.
Hickey, W. H., Jr., Southern States Equipment Corp., Hampton, Ga.
Joseph, L. J., Delgado Central Trades School, New Orleans, La.
McHenry, G., Southern Alkali Corp., Lake Charles, La.
Oglesby, S., Jr., Southern Research Institute, Birmingham, Ala.
Roberts, J. W., Allis-Chalmers Mfg. Co., Chattanooga, Tenn.
Wade, N. W., Memphis Light, Gas & Water Div., Memphis, Tenn.

5. Great Lakes

Busch, W. C., Central Ill. Elec. & Gas Co., Rockford, Ill.
Chung, C. C., Chevrolet Detroit Forge Plant, Detroit, Mich.
Dickinson, E. H., Cutler-Hammer, Inc., Milwaukee, Wis.
Dobbin, R. G., General Elec. Co., DeKalb, Ill.
Elmergreen, G. L., University of Wisconsin, Madison, Wis.
Graettinger, A. H., Allen-Bradley Co., Milwaukee, Wis.
Hopkins, A. M., Northwestern Technological Inst., Evanston, Ill.
Howlett, C. A., General Elec. Co., Fort Wayne, Ind
Johnson, J. F., Minnesota Pr. & Lt. Co., Duluth Minn.
Kershaw, F. D., P. R. Mallory & Co., Inc., Indianapolis, Ind.
Knutz, J. H. (re-election), Public Service Co. of Northern Ill., Evanston, Ill.
Lowe, J. R., Minnesota Mining and Mfg. Co., St. Paul, Minn.
Maxwell, J. R., Vern E. Alden Co., Chicago, Ill.
Peterson, V. H., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Rao, M. S., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Rehwaldt, R. A., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Roberts, F. B., The Austin Engineers, Inc., Detroit, Mich.
Smittkamp, C. J., General Motors Corp., Flint, Mich.

7. South West

Atkins, J. W., Jr., Gulf States Utilities Co., Beaumont, Tex.
Edwall, H. A., Trinity Portland Cement Co., Houston, Tex.
Francis, S. M., Jr., Westinghouse Elec. Supply Co., Little Rock, Ark.
Herman, G., Bemis Brothers Bag Co., St. Louis, Mo.
Hulan, G. R., Lower Colorado River Authority. Austin, Tex.
Noster, M. F., Southwestern Bell Tel. Co., San Antonio, Tex.
Reeves, J. W., Southwestern Bell Tel. Co., Dallas, Tex.
Senter, C. H., University of New Mexico, Albuquerque, N. M.
Wood, W. L., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Word, K. H., Southwestern Bell Tel. Co., Dallas, Tex.

8. Pacific

Chandler, M. (re-election), U. S. Naval Repair Base, San Diego, Calif.
Henry, J. A., Pacific Gas & Elec. Co., Emeryville, Calif.
Landsberger, A., Sawyer Elec. & Mfg. Co., Los Angeles, Calif.
Morris, F. W., Jr., East Los Angeles Junior College, Los Angeles, Calif.
Rist, P. E., Central Arizona Lt. & Pr. Co., Phoenix, Ariz.
Shaffer, B. B., Consolidated-Vultee, San Diego, Calif.
Wilgus, F. W., Phelps Dodge Corp., Clarkdale, Ariz.

9. North West

Johnson, A. K., Vanport Extension Center, Portland, Oreg.
Lilleberg, M. K., Boeing Aircraft Co., Seattle, Wash.
Ransom, J. C. W., United States Bureau of Mines, Pullman, Wash.
Smith, Walter R., Bobs Elec., Spokane, Wash.
Wiscombe, E. K., U. S. Bureau of Reclamation, Salt Lake City, Utah.

10. Canada

Brearley, R. J. (re-election), Gatineau Power Co., Ottawa, Ont., Canada.
Brennan, J. T., Bell Tel. Co. of Canada, Montreal, Que., Canada.
Cockburn, E. D., Amalgamated Elec. Corp., Ltd., Toronto, Ont., Canada.
Doherty, T. H., British Columbia Elec. Rwy. Co., Vancouver, B. C., Canada.
Kembley, R. A., W. Robinson & Son Converters, Ltd., Woodbridge, Ont., Canada.
Macpherson, H. W., The T. Eaton Co., Ltd., Hamilton, Ont., Canada.
McAllister, A. W., Amalgamated Elec. Corp. Ltd., Toronto, Ont., Canada.

Elsewhere

Castle, P. W., City of Birmingham Elec. Supply Dept., Birmingham, Warwickshire, England.
Chao L., M., Mexican Lt. & Pr. Co., Mexico, D. F., Mexico.
Cortes Magallanes, J., Cia. Distribuidora Westinghouse, S. A., Mexico, D. F., Mexico.
Del Valle L., R., Comision Federal de Electricidad, Mexico, D. F., Mexico.
de Rosenbaum, G. E. E., c/o SOGELEC, Jadotville, Belgian Congo.
Gnoutcheff, A., c/o SOGEFOR, Jadotville, Belgian Congo.
Holmes-Smith, E., British Thomson-Houston Co., Ltd., Rugby, England.
Hurtado, R. J., Int'l General Elec. Co., Maracaibo, Venezuela, S. A.
Kanungo, A., Indian Ordnance Factory, Bombay, India.
Nallaperumal, S., The Fertilisers & Chemicals, Travancore Ltd., Kundara, S. India.
Roebuck, A., 45 New Street, Misda, Malta.

Total to grade of Associate

United States and Canada, 113
Elsewhere, 11

OF CURRENT INTEREST

Commercial Standards Asked for Color Television

After a year of intensive tests and public and private demonstrations, executives of the Columbia Broadcasting System believe that the purely experimental stage of color television is past and have petitioned the Federal Communications Commission to adopt standards for commercial application of the CBS color television system.

In applying for a hearing, Frank Stanton, president of CBS, made the point that, so long as color television remains on an experimental basis, the industry will be subject to uncertainty, and the investment of the public and the broadcaster in low-frequency black-and-white television may be in jeopardy. CBS tests indicate that the basic technical stages have been completed, Mr. Stanton stated, and further advances must be made under commercial conditions. "As the next step in making color television available to the families of America, it is essential that the commission authorize commercial operation of ultrahigh frequency color television stations," he declared.

CBS demonstrations during the year included successful operation of a complete sending and receiving system; successful use of telephone and coaxial land lines as a means of conveying color television pictures to distant transmitters for rebroadcast; 200 broadcast demonstrations attended by more than 2,700 representatives of the government, industry, education, and the press, and, recently, live pickup using an Orthicon camera.

Consumption of Electricity by Transit Lines up for 1945

Consumption of electric energy by urban rapid transit lines showed an increase of 26,000,000 kilowatt-hours in 1945 over 1944, according to the annual summary of operations of 1,253 urban transit companies compiled by the American Transit Association.

While total consumption of electricity by the entire industry declined slightly to 6,928,000,000 kilowatt-hours, it remained considerably above the years preceding the war. Since 1926, rapid transit consumption has increased steadily with interruptions only in the depression years and during the war.

Expansion of trolley coach operations in many cities has added to the power load, the association said. Trolley coach consumption of electric power has increased rapidly and without interruption since the inauguration of the modern trolley coach in 1928. In 1945, it amounted to 415,000,000 kilowatt-hours or about six per cent of the total for the industry.

The report revealed that more than nine million dollars will be spent this year for new trackless trolley coaches and an additional 12 million dollars will be spent for new power and line construction; 22 million will be spent for new street cars, the report stated.

Power purchased from outside sources amounted to more than 69 per cent of the total consumption last year, while transit companies generated the remaining 31 per cent.

Fractional-Horsepower Motor Rating Standards Announced

A long-needed standardization plan for fractional-horsepower motors was announced by members of the motor and generator section of the National Electrical Manufacturers Association at a meeting held September 10, 1946, in New York, N. Y.

Fractional-horsepower motors now exist in such a variety of types and sizes with such differing characteristics for similar name plate data, that it is difficult to judge performance on that basis. Standards have been developed to eliminate these condition. Not only the users will benefit from the new NEMA standards, but also manufacturers and application engineers.

Most important in the new standardization plan is the basis for horsepower rating. Motors operating in the various speed ranges must meet specified breakdown torque requirements for each size. Breakdown torque is the maximum torque that a motor will exert without abrupt change in speed. Other specifications for rating include service factor and locked-rotor current maximums. Service factor is the inherent overload capacity, and, because of the relation between breakdown and full-load torque for small motors, it is higher (1.25–1.4) than the usual 1.15 value for larger ratings. Locked-rotor current standards are not new, having been adopted several years ago. C. P. Potter (F '29) chairman of the NEMA motor and generator section, presented the program of standardization.

The views on standardization expressed by various manufacturers stressed the importance of motor availability and volume production improvement, advantages to the makers, and ease of application. As a result of standardization, device and appliance manufacturers may obtain motors from a number of manufacturers and be assured of complete interchangeability, thereby assuring continuity of production in case of interruption of normal supply. Standardization and the accompanying reduction in variety of motors permits greater quantity production which results in a minimum cost. Ease of application is realized because the user is not forced to conduct exhaustive tests to determine which motor is best suited to his needs.

The standards announced are to be followed in November and December of this year by ones applying to dimensions and applications.

Sir James Jeans Dies in Surrey at 69

Sir James Jeans, physicist of international repute, well known for his interpretations of scientific concepts for the lay public, died in Surrey, England, September 17, 1946, at the age of 69.

Sir James' most original scientific work was done in cosmogony wherein he showed how gravitational instability in a chaotic mass of gas would give rise to the spiral nebulae, and how the same cause would lead to the formation of stars in the outer region of their spiral nebulae. For the laity he undertook the explanation of relativity, the quantum theory, radioactivity, atomic energy, and the transmutation of the elements.

He subscribed to the doctrine of the ultimate death of the universe, thinking that the human race was destined to die of cold while a greater part of the substance of the universe still remained too hot for life to obtain a footing. His philosophic view of modern science based it on the "uncertainty principle" which showed that determinism and cause and effect did not operate in the physical universe.

In response to an invitation from Woodrow Wilson, then president of Princeton University, Sir James joined that university in 1905 as professor of applied mathematics. Five years later he returned to Cambridge, where he lectured in mathematics for two years. He served as secretary of the Royal Society from 1919 to 1929 and also as professor of astronomy at the Royal Institution. He was knighted in 1928 and received the Order of Merit in 1939.

Among his expositions of modern physics are: "Astronomy and Cosmogony," the "Mysterious Universe," the "New Background of Science," "The Universe Around Us," and "Through Space and Time."

New Dielectric Wins Stalin Award. Discovery of a new dielectric substance by Professor Bentsion Vul, Soviet physicist and head of the laboratory of dielectrics in the Institute of Physics of the Russian Academy of Sciences, has been recognized by the award of the Stalin prize. The new substance, barium titanite, which possesses an unusually high dielectric constant, offers resistance to wide temperature changes.

Exhibitors Register for Electrical Engineering Exposition

Enrollment of a variety of exhibits, with many classifications represented by more than one exhibit, is reported by the International Exposition Company which is managing the Electrical Engineering Exposition to be held in the 71st Regiment Armory, New York, N. Y., concurrently with the 1947 AIEE winter meeting.

Nearly 100 classifications appear in the prospective list of exhibits which broadly includes electric generating and power station equipment, transmission lines and networks, substations, distribution, and maintenance. Typical of products of interest to public utilities, electrified railroads, and large industrial concerns are: generators, motors, batteries, switchboards and switchgear, solenoids, resistors, relays and regulators, rheostats, capacitors, commutators and circuit breakers, lamps and lighting fixtures for commercial and industrial uses, panelboards, gauges, and recorders. Items pertaining to transmission, distribution and load connection included cable and wire, insulators, conduits and duct, potheads, preservatives, reel racks, splices, substations, towers, transformers and converters, cutouts and fuses, motor generators, testing sets, surge protection, welders, switches, starters, and tools.

Both redesigned and newly designed equipment will be displayed at the exposition. It is expected that by the first of the year, when the exposition is held many of the engineering aspects of the postwar confusion in industry will be clarified, so that requirements arising from changes in the character of demand, expansion of networks, and new installations will be apparent. A great deal of material not now available will be placed on view, a number of items being exclusive to this display. Headquarters of the International Exposition Company are in the Grand Central Palace, New York.

Instruments in Airplanes Read From Ground by Television

"Television-telemetering," a war-developed method of checking from the ground test data in an airplane in flight, which can be extended to the testing of robot airplanes and guided missiles, recently was described by the Farnsworth Television and Radio Corporation.

The process was worked out by the Farnsworth corporation in co-operation with the Curtiss-Wright Corporation and the Navy Department. It enables observers at a ground station to see by television all instruments recordings and indicators of pressures, strains, and structural failures of a test airplane in the air. For a permanent record the data recorded on the telebision receiver is filmed as it appears on the screen.

As used by the Navy, the system consisted of a television theater and television transmitter in the airplane and a mobile television receiving unit on the ground. The television theater was a panel on which were mounted dial-type instruments, rows of small galvanometer light-beam indicators, and breakage indicator lights. The panel was faced by a 23-tube television camera which transmitted a complete image of the panel to the ground station.

The television theater and camera–transmitter units were locked together in a sealed aluminum pressure box kept to a nearly constant temperature. The box was designed to operate at an altitude of 60,000 feet. Coupled to the power amplifier, the transmitting antenna projected back from the tail of the fuselage. In this position it was in free space and only rarely affected by shadows cast by the airplane.

The mobile ground station contained a receiving unit which provided a 350-line picture, a recording unit to film all transmissions, and equipment for two-way voice radio communications with the airplane in flight. Folding antennas were mounted on the roof.

Telecommunications Conference. The United States is issuing invitations, through the International Telecommunications Union at Berne, Switzerland, for a world telecommunications conference to be held in Washington, D. C., April 15, 1947, the State Department has announced. The conference will consider revision of the Madrid Telecommunications Convention of 1932. The following countries already have indicated that they would accept:

Canada, China, Colombia, Cuba, Dominican Republic, Ethiopia, Finland, Haiti, Italy, Lebanon, New Zealand, Panama, Paraguay, Poland, Siam, Syria, Turkey, Uruguay, Vatican City, and Venezuela.

November 15 Deadline for EJC Survey. A reminder of the November 15 deadline for the return of the questionnaire on the economic status of the engineer has been issued by Engineers Joint Council which is conducting the survey jointly with the United States Bureau of Labor Statistics. Engineers who have not returned the questionnaire are asked to do so before the deadline date. Results of the questionnaire will be tabulated immediately after November 15, and Andrew Fraser of Washington, D. C., who has been engaged as consultant and liaison with the Bureau of Labor Statistics, will proceed with preparation of a report based on the replies.

Mexican Engineers Honor Steinberg. Dean S. S. Steinberg of the University of Maryland College of Engineering has been notified by President Alfonso Castello of the Association of Engineers and Architects of Mexico of his unanimous election as an honorary member of that association and as its representative to the engineering organizations in the entire Western Hemisphere in all matters dealing with closer cultural and professional co-operation. This is the fifth country that has so honored Dean Steinberg, who last year made a good will tour of Latin America for the Department of State. The others are: Ecuador, Chile, Argentina, and Uruguay.

RESEARCH • • • •

Associated Universities, Inc. Forms Atomic Research Center

The former Army camp at Camp Upton, N. Y., is being transformed into an atomic research center, Brookhaven National Laboratory, under the sponsorship of an organization of nine universities, Associated Universities Inc., Doctor Philip M. Morse, director of research for the new institution, has announced. Peacetime applications of atomic energy will be the primary purpose of the project. Funds for the center are being supplied by the United States War Department, which is making an initial appropriation of $5,000,000.

A cyclotron of 20,000,000 to 30,000,000 volts and possibly a large one of 500,000,000 volts and a synchrotron of comparable size, as well as a chain-reacting uranium pile, will be erected on the site. Ten to 12 buildings will house biological, chemical, physical, medical, and engineering research groups on the 3,700-acre tract.

The sponsoring universities are: Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, Pennsylvania, Princeton, Rochester, and Yale. Edward Reynolds of Harvard is president of the new organization, and the scientists employed will not be limited to co-operating schools. In addition, arrangements are being made so that graduate students may carry on their thesis research at the laboratory and get advanced degrees from a university. Choice of the students will not be restricted to those attending the nine schools.

Army's Research Division Plans for Civilian Co-operation

The task of putting into effect the War Department's new research and development policy announced by General Dwight D. Eisenhower in April 1946 has been entrusted to Major General Henry S. Aurand as head of the newly created Research and Development Division of the War Department General Staff.

As director of the division, General Aurand is key figure in the War Department's application of national scientific resources to the solution of military problems. He is adviser to the Secretary of War and the Chief of Staff on all War Department matters relating to research and development.

The revised policy drawn up in April by General Eisenhower under which the new division is operating stresses the Army's realization of the need for continued peacetime reliance on civilian assistance in military planning as well as in the production of weapons. Scientists and industrialists are to be given the greatest possible freedom in their research, and within the Army the responsibility for research and development are to be separated from functions of procurement, purchase, storage, and distribution, General Eisenhower has decided.

In line with this, General Aurand now is bringing into the new division on an annual rotation basis, a group of top-flight engineers and scientists recruited from the laboratories of educational institutions, foundations, and industries. They will assist him in the same manner as military personnel assigned to the division.

A War Department civilian panel of outstanding scientists and engineers is being created, representing both the natural and the social sciences. The members of this panel, individually and in groups, will collaborate in the solution of special planning and technical problems.

General Aurand is endeavoring to give freedom of research to the contractual relationship between the Army and the universities, industries, and foundations now conducting research and engineering for it. Within the limits of present laws governing government contracts, all possible freedom will be given. Furthermore, he is advocating a change in the contract law to permit even greater freedom to scientists and engineers.

Industrial Research Institute at Stanford. Establishment of Stanford Research Institute, a nonprofit organization, which will carry on research projects for industry on the Pacific Coast, has been announced by Doctor Donald B. Tresidder, president of Stanford University. Conceived with the aid of leading industrialists of southern and central California and the Pacific Northwest, the institute will be located on the campus of Stanford University and will include within its scope pure and applied research in the physical, biological, and social sciences and in engineering and the mechanical arts. Director of the institute will be Doctor William F. Talbot, president and technical director of the fine chemicals division of the Sun Chemical Corporation.

Admiral Assails Naval Research Cut. Profound discouragement with what the Bureau of the Budget is doing to the Navy was given by Rear Admiral Luis de Flores, Deputy Chief of Naval Research, as one reason for his retirement on October 1. Admiral Flores, Deputy Chief of Naval Research, returned to the presidency of his own consulting engineering firm in New York, N. Y. "It is heartbreaking to me," he said, "to see what is happening to the entire military and Navy establishment now, particularly when national security is so extremely vital." He asserted that the new technological age has forced a staggering research and development job, amounting almost to complete reconversion, on the Navy and that the $45,000,000 which has been granted to do that job "is like handing over a hairpin with which to pick the locks of the gold vaults at Fort Knox."

INDUSTRY • • • • •

New Steel-Frame Motor Manufactured by Westinghouse

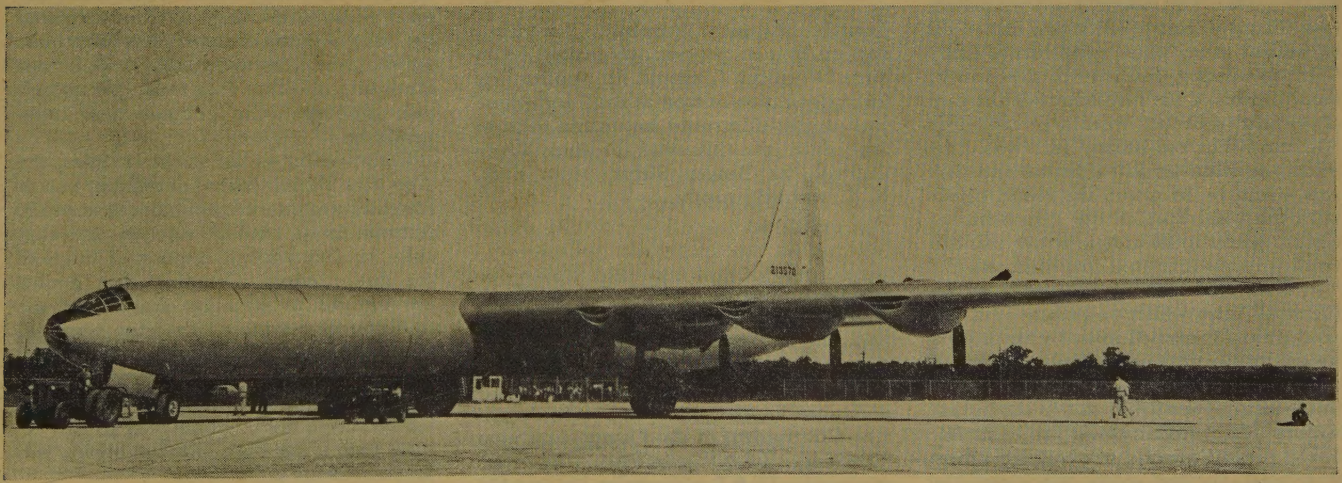
The Westinghouse Electric Corporation has introduced a new line of integral-horsepower steel-frame squirrel-cage induction motors which is called an unusual advance above the normal rate of progress.

Some of the major construction features claimed in the new motor are decreased size and weight, increased strength and shock resistance, interchangeability of parts, more easily installed coils, prelubricated ball bearings, and improved appearance. Vibration and noise also have been reduced.

An outstanding factor in the improvement of the motor is the substitution of steel in place of cast iron for parts such as end frames and pedestals. Size reduction of about 35 per cent and in some designs weight reduction of 50 per cent is reported. Much of the size and weight reduction is possible because dimensions of the formed steel parts can be held within closer limits than cast iron parts, thereby eliminating the large allowances necessary to establish minimum clearances. Also contributing to the size and weight reduction is an improved cooling system which requires less heat transfer surface.

Replacing cast iron with steel has resulted in a motor of greater strength and ruggedness, because the structural sections are as thick as those made of cast iron. Increased ruggedness is related directly to

Six-Engine Airplane Has Special Landing Problems



The world's largest airplane, the Army Air Forces' Consolidated-Vultee XB-36, is shown at the manufacturer's Fort Worth, Tex., airfield, one of the three in the United States equipped with the 300,000-pound runways which the B-36's 278,000-pound gross operating load requires. The other fields are the Fairfield-Suisun Army Air Base, northeast of San Francisco, and the Air Forces Proving Ground, Eglin Field, Fla. For a better distribution of weight during landing operations, future models of the B-36 will have four wheels to each main landing gear strut, and two for the nose wheel. The craft has an over-all length of 163 feet and a wing span of 230 feet. It is powered by six Pratt and Whitney engines producing a total of 19,000 horsepower. Its fuel capacity makes possible nonstop flights of more than 10,000 miles

the ability of steel to resist shock better than cast iron. Improved appearance is possible because formed steel presents a much smoother surface than cast iron.

Extensive interchangeability of parts makes possible several types of motors which utilize the same basic frame, stator, and rotor. It is a simple matter to convert an open-protected or dripproof motor into a splashproof or a totally enclosed fan-cooled motor by changing end brackets, hoods, and fans.

Decreased maintenance requirements have been achieved through simplification of winding installations and use of prelubricated ball bearings. Most winding failures are traced to damage incurred during insertion of coils in their slots. Design of the new motor incorporates slot shapes and sizes which permit easier installation of coils with shortened end extensions, thereby reducing damage to insulation.

Electric Power From Atomic Energy Held Feasible

According to a report made to the Westinghouse Electric Corporation by Doctor J. A. Hutcheson (M '44) associate director of the research laboratories and C. F. Wagner (F '40) manager of the central station engineering department, the economical production of electric power from atomic energy may not be far off.

The report compares the costs of an atomic-powered and a coal-fired power plant and concludes that technical problems rather than economic ones are the problems which must be solved before the atomic power plant is practical. For purposes of comparison the report assumes that an atomic powered 100,000-kw plant would be built in which the cost of the equipment and plant necessary to provide steam for the turbines would be about $12,000,000. This would be approximately four times the cost of the steam end of an equivalent power plant using coal as fuel.

In calculating the cost of the power, amortization of the investment at the rate of 15 per cent per year was included. Assuming that the atomic fuel would be refined uranium at $20 a pound and that coal would be $5 a ton, the report calculates the total cost of the generation of electric power in an atomic power plant to be slightly less than in a coal fired plant.

It is inferred that the heat given off by the stock piles which at present is a by-product and is carried away by air or by a stream of water must amount to many thousands of kilowatts of power. From this the assumption it follows that the earliest applications of atomic power will be similar to the present method of obtaining power from coal, in that steam will drive the turbine and that heat liberated from the fission of some material will be used to form the steam.

Problems new to the electrical industry will be those presented by the replacement of the present boiler and coal combustion equipment with some suitable heat exchanger and atomic power equipment. Special shielding equipment to confine dangerous radiations emanating from the uranium fuel will be needed. Since the steam passing through the turbine probably will be radioactive as well as the by-products of fission, special methods for handling, storing, and removing them will be needed.

Mexican Electrical Company Organized. Formation of Industrial Electrica de Mexico, S. A., has been announced by the Westinghouse Electric Corporation, Pittsburgh, Pa., with which the new company has a long term license agreement providing that the Westinghouse corporation will supply specifications and drawings for all products manufactured, as well as information on production methods. Personnel training for the new company also will be undertaken by the Westinghouse corporation which will bring groups of trainees to the United States. The Mexican company, which will be located north of Mexico, D. F., has a capitalization of $15,000,000, one third of which has been loaned by Nacional Financiera, an agency of the Mexican Government, and two thirds of which has been subscribed equally by Mexican and United States investors. The products to be manufactured include such basic equipment as transformers, circuit breakers, panelboards and distribution panels, motors, and controls, as well as household appliances. Limited production at the plant is expected to begin by the end of 1946, and the estimated demand for the company's products is about $10,000,000. J. W. White (A '29) formerly president and general manager of the Westinghouse Electric International Company, New York, is director general of the new company.

French Patent Warning. Americans owning French patents, which will be in force December 1, should file applications for prolongation as soon as possible because such applications must be on file prior to that date, the National Foreign Trade Council, 23 Beaver Street, New York, N. Y., warned recently.

Argentina Purchases IT & T Subsidiary. Argentine President, General Juan Peron, and Colonel Sosthenes Behn, president of the International Telephone and Telegraph Company, recently completed negotiations for the purchase by the Argentine Government of the Compania Union Telefonica, IT&T subsidiary. By terms of the sale, IT&T will receive $94,991,324 for its common and preferred stock holdings and two ten-year contracts giving it exclusive right to supply telephonic equipment to its former subsidiary and making it technical adviser in the operation of the system. The Argentine Government also will assume debentures which are outstanding in the Argentine, Swiss, and Swedish markets. At the ceremony marking the transfer of ownership, which was attended by United States Ambassador George S. Messersmith, Colonel Behn praised the Peron Government for repatriating "foreign owned public services by means of across-the-table dealings rather than by recourse to expropriation proceedings."

EDUCATION • • •

Scientists Ask Safeguard From Domination by Government

That American universities must beware lest Government funds granted for research become a controlling influence on those institutions was the consensus of the scientists attending the Princeton University bicentennial conference on the future of nuclear science.

The risk the universities run in accepting Government funds was emphasized by Doctor L. I. Rabi, professor of physics at Columbia University, who stated that there would be no better way for the Government to gain control of the universities than by the contribution of large funds for research.

"It would be a pity," he said, "if the full support which is available in certain fields of research serves to divert some scientists from following the full play of their imaginations. It would make for far healthier conditions, if the Government funds which have been made available for research were more in the nature of general grants rather than for specific objectives, and if the funds could be used in the same way as ordinary research funds."

In the discussion from the floor by scientists and educators, there was general agreement with Doctor Rabi. It was suggested by various speakers that universities must set the terms on which they will accept funds and also that they must look to private endowments to preserve their independence.

Commenting on the scientists' fears, the *New York Herald Tribune* noted that one of the chief characteristics of modern scientific research is its tremendous cost and that only the Government disposes of funds of the size needed. Granting that doubts are natural to scientists trained in the tradition of privately supported research, the *Tribune* concludes, however, "The trend (to Government support) is there and the fears are there; one can only hope that a Government, more enlightened in this respect than it has been in many others, will prove the fears unjustified."

Graduate Division in Mathematics. Brown University has announced the formation of a graduate division of applied mathematics as an interdepartmental project of the departments of physics and mathematics. Instruction will stress research for advanced students in engineering, physics, and mathematics. Undergraduate students who have superior records in two of the three fields occasionally will be admitted. Fellowships for the studies have been provided by the Rockefeller Foundation through the academic year 1950–51.

JOINT ACTIVITIES

Washington Award Commission. Composition of the Washington Award Commission for 1946–47 has been announced by the Western Society of Engineers. Representatives of the societies making up the commission are:

Western Society of Engineers
F. G. Gordon, M. M. Leighton, William V. Kahler (M '39) *chairman;* C. Earl Webb, Philip Harrington, Homer K. Smith (F '44), P. R. Elfstrom, H. H. Morgan, J. deN. Macomb.

American Society of Civil Engineers
Ralph H. Burke, C. B. Burdick.

American Institute of Mining and Metallurgical Engineers
G. P. Halliwell, J. E. Drapeau, Jr.

American Society of Mechanical Engineers
John R. Michel, Ralph E. Turner.

American Institute of Electrical Engineers
Harry B. Gear (F '20), M. S. Coover (F '42).

OTHER SOCIETIES •

Societies Hold Concurrent Meetings. The 1946 winter meetings of the Electron Microscope Society of America and the American Society for X-ray and Electron Diffraction will be held in Pittsburgh, Pa., from December 5 to 7, at the Mellon Institute of Industrial Research. Joint sessions of the two societies may be arranged if the programs so permit. Joint dinners for December 5 and 6 already have been planned. Information concerning these meetings may be obtained from Doctor S. S. Sidhu, local chairman of the ASXRED, University of Pittsburgh, or from Doctor Earl A. Gulbransen, local chairman of the EMSA, Westinghouse Research Laboratories, East Pittsburgh, Pa.

Future Meetings of Other Societies

American Welding Society. Annual meeting, November 17–22, 1946, Atlantic City, N. J.

American Society for Testing Materials. Spring meeting and committee week, February 24–28, 1947, Philadelphia, Pa.

National Electrical Contractors Association. Annual meeting, October 14–18, 1946, Atlantic City, N. J.

National Exposition of Power and Mechanical Engineering. December 2–7, 1946, New York, N. Y.

National Research Council. Conference on Electrical Insulation, November 7–9, 1946, Johns Hopkins University, Baltimore, Md.

Chemical Society Employment Service. Organization of a nation-wide employment service for the chemical profession in seven key cities has been announced by Alden H. Emery, national secretary of the American Chemical Society. Through the facilities of the offices, an employer anywhere in the United States can obtain information about any chemist or chemical engineer in the country who is seeking employment by visiting the nearest regional office. Records of all registrants are available in duplicate form at all seven offices. To assure uniformity of information, all application forms are sent to Washington, where they are processed, numbered, and duplicated. Index cards giving the principal facts about the registrant are prepared, one being placed in an alphabetical file and duplicates in various sections of an experience file, according to the fields of specialization in which the applicant has indicated training or experience. The service has its headquarters in Washington, D. C., and maintains offices in New York, N. Y.; Atlanta, Ga.; Boston, Mass.; Chicago, Ill.; Houston, Tex.; and San Francisco, Calif.

International Standards Association. P. G. Agnew (M '19) secretary, American Standards Association, and E. C. Crittenden (F '44) assistant director, National Bureau of Standards, were the American delegates to the conference setting up the International Standards Association. Twenty nations were represented at the conference which met in London, October 14–26.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Carrier Supervisory Control of Pumping Station

To the Editor:

The valuable technical paper by W. A. Derr, W. A. Keller, and H. A. W. Hedke, (*EE, Nov '46, pp 699-705*) omits certain background material that is needed for its proper evaluation.

First of all, the adoption of carrier supervisory control for the pumping station of the United States Sugar Corporation in Lake Okeechobee, Fla., is an excellent example of the adage that an engineer's best friend is a competent sales engineer.

Trouble arose in 1943–44 over obtaining authority from the War Production Board for the copper needed in the power and control cables that were first proposed. The J. B. McCrary Engineering Corporation, Atlanta, Ga., was preparing detail drawings and specifications for the water-treatment plant and its lake pumping station. I was employed as engineer for Bitting, Inc., New York, N. Y., which at that time was supervisory manager for the sugar corporation. Sales representatives of the Westinghouse Electric Corporation came to me in Atlanta and to the engineers of the J. B. McCrary Engineering Corporation, in the winter of 1943–44, with the proposal that carrier current be tried. An investigation showed its probable merit. J. H. Temple and B. E. B. Snowden, engineers for McCrary, and I joined in the preparation of a discussion of the cost, copper required, and advantages and disadvantages of the various methods that might be used in controlling the pumping station in its possible locations on the shore and in the lake. This discussion when presented to WPB resulted in the approval of carrier current because of the saving in copper. The cost incidentally was estimated as slightly less than other methods of control.

Secondly, Lake Okeechobee being shallow is particularly dangerous to life in a high wind, as bad wave action is quickly aroused. Such waves can be expected in frequent thunderstorms in the summer and of course in hurricane weather. Waves probably will sweep at times over the pumping station. Control of the equipment in the pumping station and methods of checking its satisfactory operation at frequent intervals were therefore necessary. The supervisory control permits, for example, the checking of bearing and cooling water temperatures.

Finally, the starch plant has a designed capacity of 120 tons daily of sweet-potato starch. Inability to operate such a plant in bad weather because of inability to control the pumping of water runs quickly into large sums of money. It was believed, further, that eventually water pumped from the lake would be sold to the City of Clewiston and thus a human and fire hazard was introduced if water was not obtainable at all times. Fire insurance rates at the starch plant and in the City of Clewiston on company property and on employee's homes also were involved. These factors justified extraordinary measures to assure uninterrupted operation of the pumping station.

GREGORY M. DEXTER

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NEW BOOKS • • •

"Considérations sur le Problème de la Stabilité Contribution a l'Etude des Régulateurs de Vitesse (Considerations of the Problem of Stability, A Contribution to the Study of Speed Governors)." The author of this text is well known for his work on hydraulic problems—in particular the joint publication of this author, and Jules Calame, "Theory of Surge Tanks." The present work deals first with the elementary theory of the regulation of water turbines, neglecting water hammer, and then with the effect of water hammer on the regulation, a particularly interesting chapter being devoted to the study of the effect of a sinusoidal movement of the governor. The author shows that the result is a sinusoidal pressure oscillation, out of phase with the governor movement. From this follows an analytical discussion of the effect of water hammer on the regulation, and of the conditions necessary for hydraulic stability. A chapter of particular interest to electrical engineers concerns the vectorial treatment of the conditions of stability. A chapter is devoted to the regulation of two or more units operating in parallel. Governor accessories and variants in governing procedure are given a chapter to themselves. Three appendixes are devoted to overspeed due to dropping load, penstocks of multiple characteristics, and the measurement of the characteristic time of promptness of response. The work is marked by clarity and thoroughness, even to the point of some repetition. The author is connected with a large European turbine manufacturer, and this reviewer would hazard the supposition that the book is the result of considerable experience with cases of difficult hydraulic conditions leading to actual or potential instability. It is regrettable that actual examples of such conditions are not illustrated more fully along with the means adopted to overcome them. The European engineer is perhaps more conscious of the threat of hydraulic instability than is the American engineer, whose machines in nearly every case are tied in to state-wide or region-wide networks, and specific examples of instability which may have arisen in European practice could be most informative. By Daniel Gaden. Editions la Concorde, Lausanne, Switzerland, 1945, $6^{1}/_{4}$ by $9^{1}/_{4}$ inches, 253 pages, illustrated, paper 21 Swiss francs, cloth 27 Swiss francs. (Review contributed by Robert A. Sutherland of Ebasco Services Incorporated, New York, N. Y.)

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ENDLESS HORIZONS. By V. Bush. Introduction by F. B. Jewett. Public Affairs Press, Washington, D. C., 1946. 182 pages, portrait, $9^{1}/_{4}$ by 6 inches, cloth, $2.50. Ranging from the quietly humorous "The Inscrutable Past" to the practically suggestive "Science for World Service," these forward-looking 17 papers demonstrate the versatility of Doctor Bush. In the varied fields under consideration, shortcomings are demonstrated, present achievements are assessed, and remedies and goals are proposed.

LEGAL PHASES OF CONSTRUCTION CONTRACTS. By I. V. Werbin. McGraw-Hill Book Company, New York, N. Y., and London, England, 1946. 267 pages, $8^{1}/_{2}$ by $5^{1}/_{4}$ inches, cloth, $2.75. The author discusses 46 different legal problems that have arisen in connection with construction contracts, of practical interest to engineers, architects, contractors, and attorneys. The book shows the court precedents that have been established on these problems and gives, in many cases, the actual language of the contract provisions and also the facts involved. The intent is to provide the layman without legal training or experience an understanding of the import of the courts' decisions.

LINCOLN'S INCENTIVE SYSTEM. By J. F. Lincoln. McGraw-Hill Book Company, New York, N. Y., and London, England, 1946. 192 pages, illustrated, 9 by $5^{3}/_{4}$ inches, cloth, $2. Incentive management, as outlined in this book, goes beyond the ordinary conceptions of incentive pay. It is a philosophy of industry and life, which starts with the needs of society and depends primarily for its success on the development in the individual of his latent abilities. It is not only a method of wage payment; it is an economic system. The book presents exact data and results of the application of the system and demonstrates how it can be put into effective use in any plant.

QUARTZ CRYSTALS FOR ELECTRICAL CIRCUITS. By R. A. Heising. D. Van Nostrand Company, New York, N. Y., 1946. 563 pages, illustrated, $9^{1}/_{4}$ by 6 inches, cloth, $6.50. The piezoelectric property of quartz has caused a rapid growth in recent years in the use of quartz plates in electric circuits, particularly for radiotelephony. Some 16 specialists have contributed the separate chapters of this book, discussing the development of this application of quartz crystals, demonstrating methods for determining their desirable qualities, and describing the manufacturing and testing processes by which they are made effective for the purpose. The mounting of quartz plates is covered in detail, and their plating with thin metal films for use as electrodes is given special consideration.

SOUL OF LODESTONE. By A. Still. Murray Hill Books, New York, N. Y., and Toronto, Ontario, Canada, 1946. 233 pages, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $2.50. A companion volume to the author's "Soul of Amber," this book does for magnetism what the previous book did for electricity. It provides a history of man's thoughts concerning magnetism and of the uses to which it has been put, beginning with the very earliest records and carrying on up to the point where the ever closer relationship between electricity and magnetism becomes the science of electromagnetism. Considerable direct quotation brings out the flavor of the periods under consideration, and extensive notes and references are provided.

WHAT ARE COSMIC RAYS. By P. Auger. Translated from the French by M. M. Shapiro. University of Chicago Press, Chicago, Ill., 1945. 128 pages, illustrated, $7^{3}/_{4}$ by $5^{1}/_{4}$ inches, cloth, $2. This book presents a simple, straightforward account of all the major cosmic-ray phenomena for the reader who lacks a technical knowledge of physics. A translation from the original French, the new edition has been revised in the light of recent new discoveries and important changes in the field of cosmic rays. The history of the development of cosmic-ray research is reviewed in the early chapters, and a number of photographs of tracks of electrified particles included.

X RAYS IN PRACTICE. By W. T. Sproull. McGraw-Hill Book Company, New York, N. Y., and London, England, 1946. 615 pages, illustrated, 9 by $5^{3}/_{4}$ inches, cloth, $4. The history, fundamentals, and characteristics of X rays and X-ray spectra serve as the introduction to this comprehensive work. With emphasis on the practical aspects, the book proceeds with the generation, absorption, scattering, and diffraction of X rays; the measurement and recording of X rays; and descriptions of X-ray equipment. Particular applications dealt with include: industrial radiography, medical applications, crystallography, fluoroscopy, microradiography, and numerous minor uses.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers

Standard Code for Arc and Gas Welding in Building Construction. American Welding Society, 33 West 39th Street, New York 18, N. Y., 68 pages, 50 cents.

Surplus Property. War Assets Administration, Railroad Retirement Building, Washington 25, D. C., 29 pages.

Nucleonics. Based on material prepared under the auspices of the United States Navy Department. Progress Press, 2153 Florida Avenue, Washington 8, D. C., 38 pages, $1.

The Geiger-Muller X-Ray Spectrometer. By F. G. Firth. North American Philips Company, Inc., 100 East 42d Street, New York 17, N. Y., 8 pages, no charge.

What Switch Shall I Use? Delta-Star Electric Company, 2400 Block, Fulton Street, Chicago 12, Ill., no charge.

The Plastics Industry. By Barrett L. Crandall. Bellman Publishing Company, Inc., 83 Newbury Street, Boston 16, Mass., 36 pages, $1.

Electrical Porcelain. By John C. Lebens, Jr. National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y., 20 pages.

Model K, Dillon Universal Tester. W. C. Dillon and Company, Inc., 5410 West Harrison Street, Chicago 44, Ill., 15 pages, no charge.

A Procedure for Testing the Locking Effectiveness of Self-Locking Nuts and Related Fastening Devices. By J. A. Sauer. Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, N. J., 16 pages.

Handbook of Farmstead Wiring Design. Industry Committee on Interior Wiring Design, Room 2650, 420 Lexington Avenue, New York, N. Y., 55 pages, single copies 40 cents, quantity prices on application.

Articles and Books on Spectrography, 15 pages. **Articles and Books on Industrial Photo-reproduction,** 7 pages. Industrial Photographic Sales Division, Eastman Kodak Company, 343 State Street, Rochester 4, N. Y., no charge.

MIMA News. This is a new four-page quarterly published by the Magnesia Insulation Manufacturers Association, 1317 F Street, N. W., Washington, D. C., for those interested in heat insulation.